Engström Ventilator

Technical Reference Manual

Datex-Ohmeda products have unit serial numbers with coded logic which indicates a product group code, the year of manufacture, and a sequential unit number for identification. The serial number can be in one of two formats.

AAA**X**11111	AAA**XX**111111AA
The **X** represents an alpha character indicating the year the product was manufactured; **J** = 2004, **K** = 2005, etc. **I** and **O** are not used.	The **XX** represents a number indicating the year the product was manufactured; **04** = 2004, **05** = 2005, etc.

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Engström Ventilator

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Important

The information contained in this Technical Reference manual pertains only to those models of products which are marketed by Datex-Ohmeda as of the effective date of this manual or the latest revision thereof. This Technical Reference manual was prepared for exclusive use by Datex-Ohmeda service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, Datex-Ohmeda provides this Technical Reference manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities may be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that customer has received such information from Datex-Ohmeda does not imply in anyway that Datex-Ohmeda deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, may not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers. Send your comments and suggestions to the Manager of Technical Communications, Datex-Ohmeda, Ohmeda Drive, PO Box 7550, Madison, Wisconsin 53707.

⚠ CAUTION Servicing of this product in accordance with this Technical Reference manual should never be undertaken in the absence of proper tools, test equipment and the most recent revision to this service manual which is clearly and thoroughly understood.

Technical Competence

The procedures described in this Technical Reference manual should be performed by trained and authorized personnel only. Maintenance should only be undertaken by competent individuals who have a general knowledge of and experience with devices of this nature. No repairs should ever be undertaken or attempted by anyone not having such qualifications.

Datex-Ohmeda strongly recommends using only genuine replacement parts, manufactured or sold by Datex-Ohmeda for all repair parts replacements.

Read completely through each step in every procedure before starting the procedure; any exceptions may result in a failure to properly and safely complete the attempted procedure.

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1 Introduction

In this section

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1.1 What this manual includes

This manual covers the service information for the Engström Ventilator.

It covers the following components:

- Display Unit
- Integral electronics
- Gas delivery components
- Frame component

Other equipment

Other equipment may be attached to the system. Consult separate documentation relative to these items for details.

1.2 User's Reference manuals

Some sections of this manual refer you to the User's Reference manual for the Engström Ventilator. To expedite repairs, you must have, and be familiar with, the User's Reference manual for this product.

Refer to the Engström Ventilator User's Reference manual if you need further information about the operation of the system.

Conventions used

Hard keys

Names of the hard keys on the display and modules are written in bold typeface, for example, **Normal Screen**.

Menu selections

Menu selections are written in bold italic typeface, for example, ***Patient Setup***.

Messages

Messages that are displayed on the screen are enclosed in single quotes, for example, 'Check sample gas out.'

Sections and headings

When referring to different sections or headings in the User's Reference manual, the name is written in italic typeface and is enclosed in double quotes, for example, *"System Controls and Menus."*

1.3 What is an Engström Ventilator?

The Engström Ventilator (EV) is a flexible, adaptable, and intuitive critical care ventilator. A wide selection of performance options gives the user full control of the system configuration.

The EV must only be operated by authorized medical personnel well trained in the use of this product, for patient ventilation in the intensive care environment. It must be operated according to the instructions in this User's Reference manual.

The ventilator is designed to be used with infant through adult patients with a body weight of 5 kg or greater. The EV is designed to maintain lung ventilation in the absence of spontaneous breathing effort as well as in support of the patient's existing spontaneous breathing effort.

The system is designed for facility use, including within-facility transport.

The ventilator consists of three main components: a display, a ventilator unit, and an optional module bay. The display allows the user to interface with the system and control settings. The ventilator unit controls electrical power, nebulization, and pneumatic gas flow to and from the patient. The module bay allows the integration of various patient monitoring modules with the ventilator.

Optional accessories include an air compressor, airway modules, module bay, humidifier and water trap mounting brackets, and auxiliary electrical outlets.

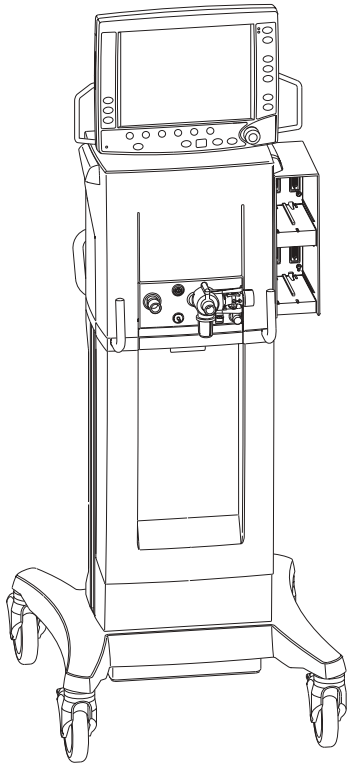
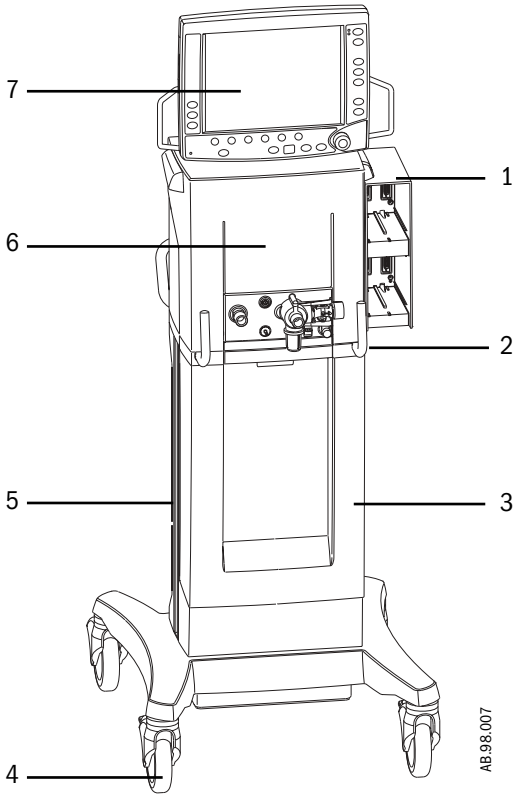
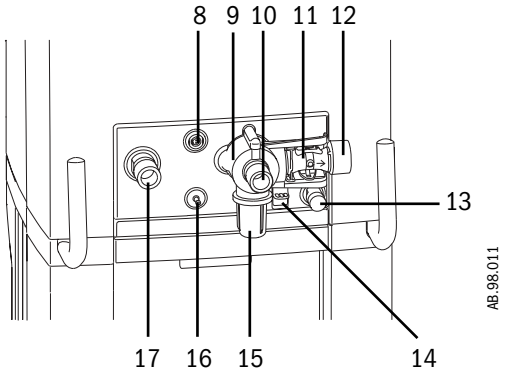


Figure 1-1 • Engström Ventilator (EV)

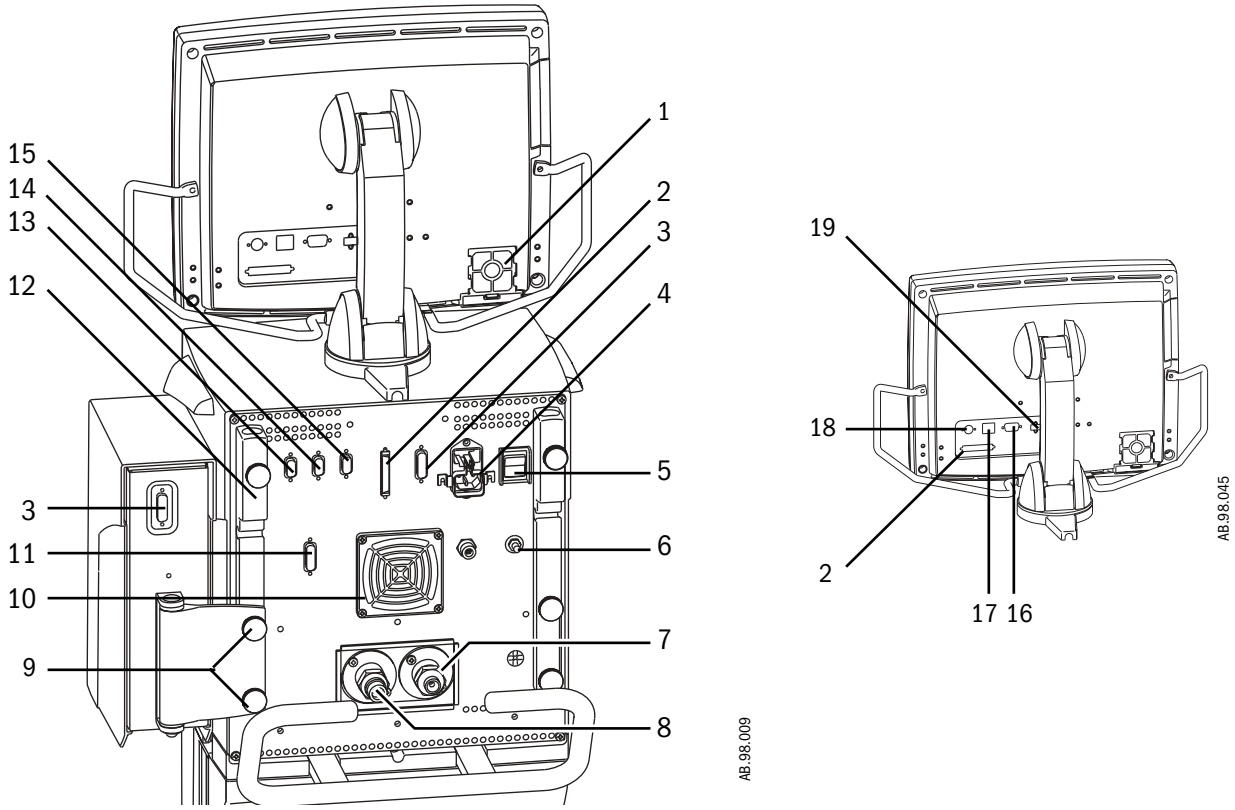
1.4 Ventilator overview





1. Module bay (optional)
2. Ventilator lock [locks Ventilator unit (item 6) to Cart (item 3)]
3. Cart
4. Caster
5. Dovetail rails
6. Ventilator unit
7. Display
8. Nebulizer connection
9. Exhalation valve housing
10. Expiratory inlet
11. Expiratory flow sensor
12. Gas exhaust port
13. Leak test plug
14. Exhalation valve housing latch
15. Water trap
16. Auxiliary pressure port
17. Inspiratory outlet

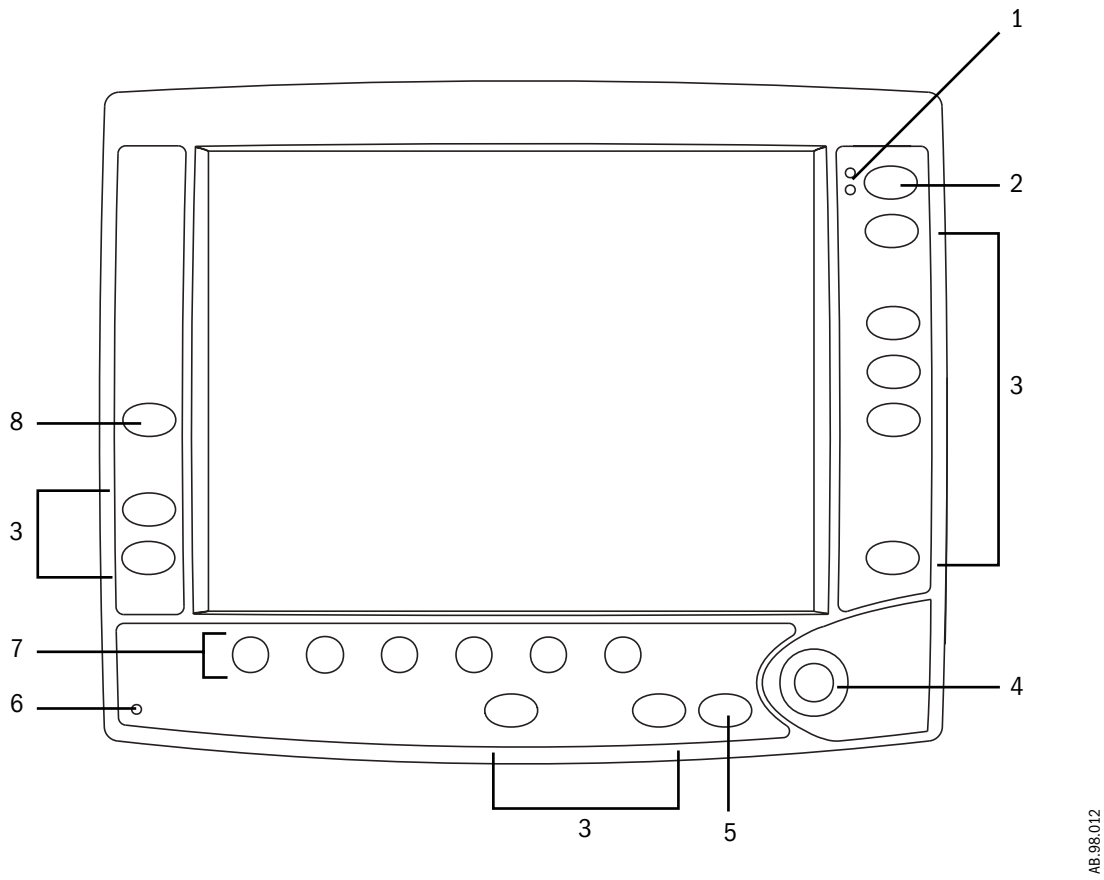
Figure 1-2 • Front view of the EV



1. Display fan filter
2. Display connection
3. Module bay connection
4. AC mains inlet
5. System switch
6. Equipotential connector
7. Oxygen supply connection (pipeline)
8. Air supply connection (pipeline or compressor)
9. Module bay mounting thumbscrews
10. Ventilator unit fan filter
11. Serial communication port (RS 232 port)
12. Arm holder
13. RS 485 port (not currently supported)
14. RS 485 port (not currently supported)
15. RS 422 port (used to communicate with PC based Service Application — Refer to Section 8.5)
16. Network ID connection
17. Ethernet connection
18. DIS port (not currently supported)
19. USB port

Figure 1-3 • Back view of the E V

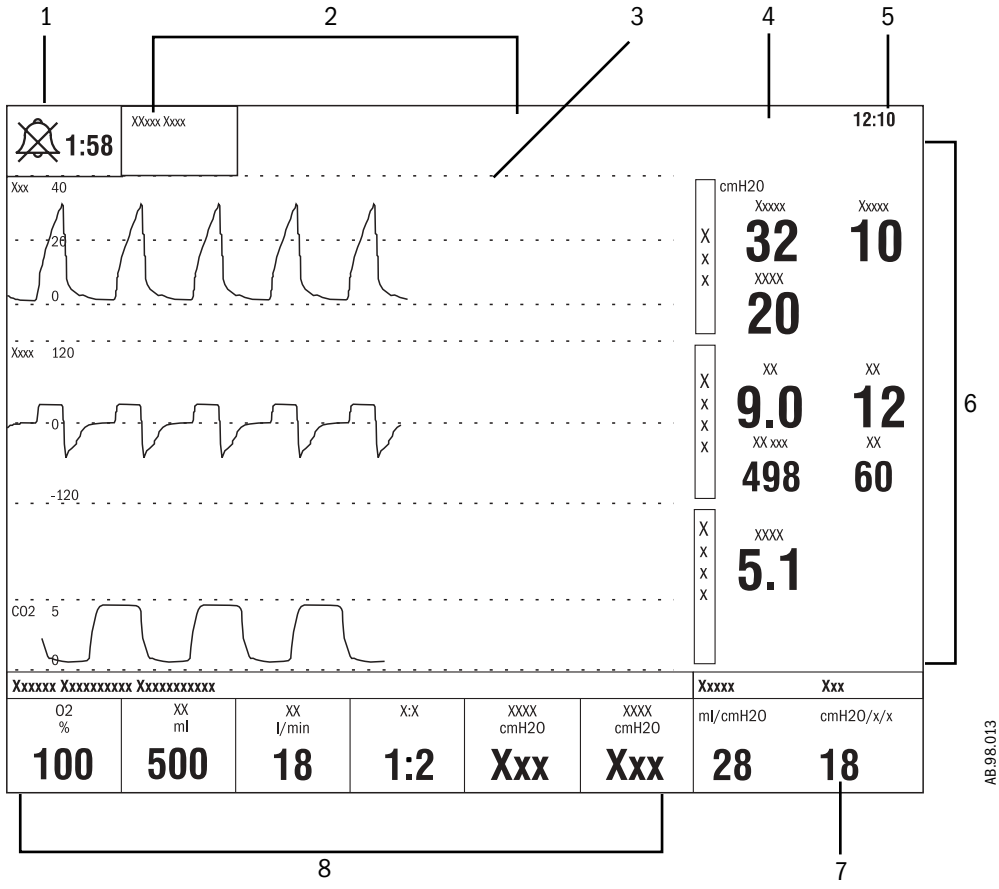
1.5 Display controls and indicators



1	Alarm LEDs	The red and yellow LEDs indicate the priority of active alarms.
2	Alarm Silence key	Push to silence any active, silenceable high and medium priority alarms or to suspend any non-active medium priority alarms. Alarm audio is silenced or suspended for 120 seconds. Push to clear resolved alarms.
3	Menu keys	Push to show corresponding menu.
4	ComWheel	Push to select a menu item or confirm a setting. Turn clockwise or counterclockwise to scroll menu items or change settings.
5	Normal Screen key	Push to remove all menus from the screen.
6	AC mains indicator	The green LED lights continuously when the EV is connected to an AC mains source. The internal batteries are charging when the LED is lit.
7	Quick keys	Push to change corresponding ventilator setting. Turn the ComWheel to make a change. Push the Quick key or ComWheel to activate the change.
8	100% O2 key	Push to deliver 100% O_2 for 2 minutes.

Figure 1-4 • Controls and indicators

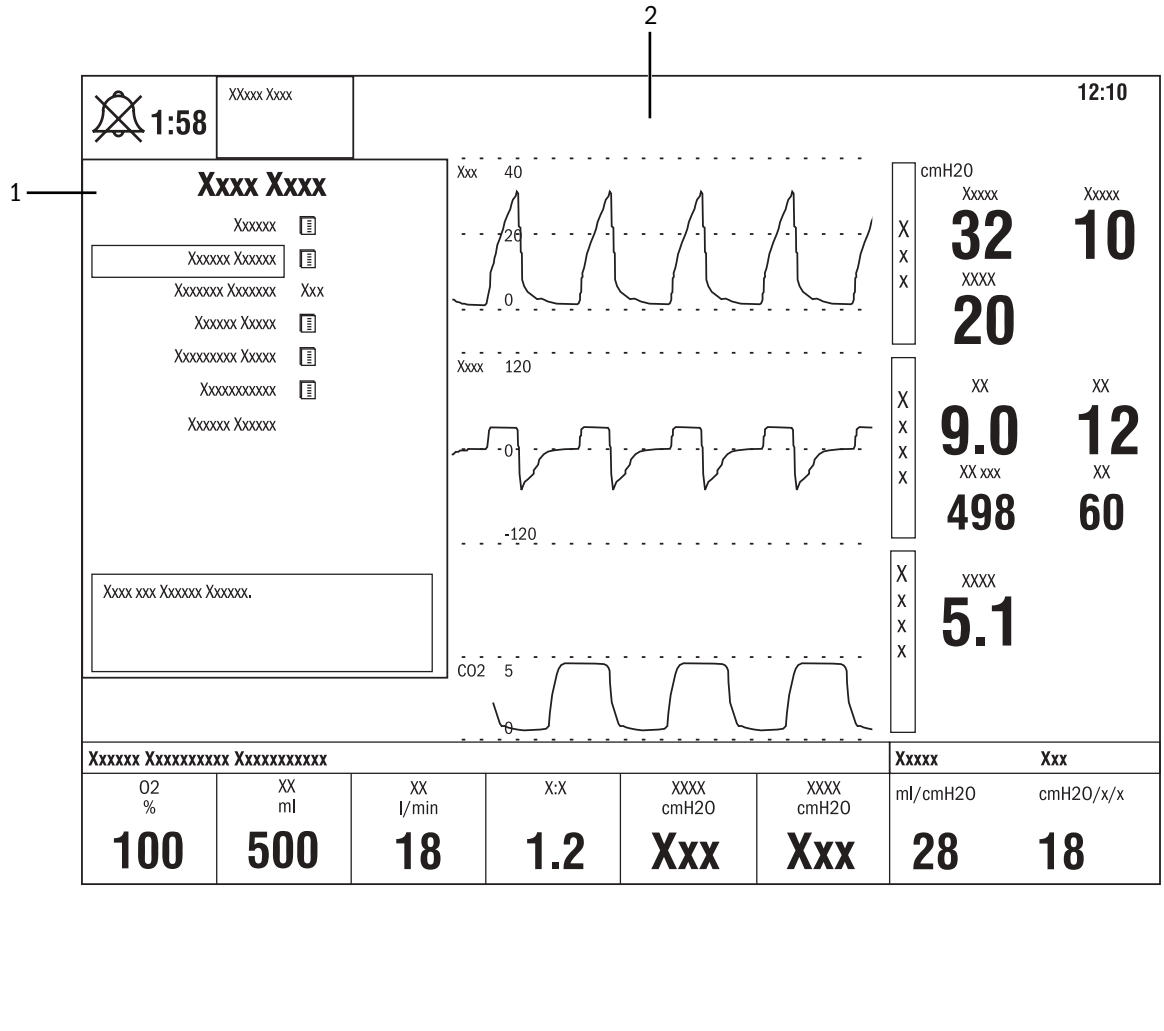
1.6 Ventilator display



1	Alarm silence symbol and countdown	Displays the time remaining during an alarm silence or alarm suspend period.
2	Alarm message fields	Alarms will appear in order of priority. Refer to *"Alarms and Troubleshooting"* for more information on alarm behavior.
3	Waveform fields	The top two waveforms are permanently set to Paw and Flow. The third waveform may be selected as CO_2, O_2, Vol, Paux, or Off.
4	General message field	Displays informational messages.
5	Clock	The time may be set in 12 or 24 hour format in the Time and Date menu.
6	Measured value fields	Displays current measured values corresponding to the waveforms.
7	Digit field	Displays information related to Volume, CO_2, O_2, Compliance or Spirometry.
8	Ventilator settings	Displays several of the settings for the current mode of ventilation.

Figure 1-5 • Normal Screen view

When a menu key is selected the waveform fields start at the right edge of the menu. The entire waveform is always displayed.



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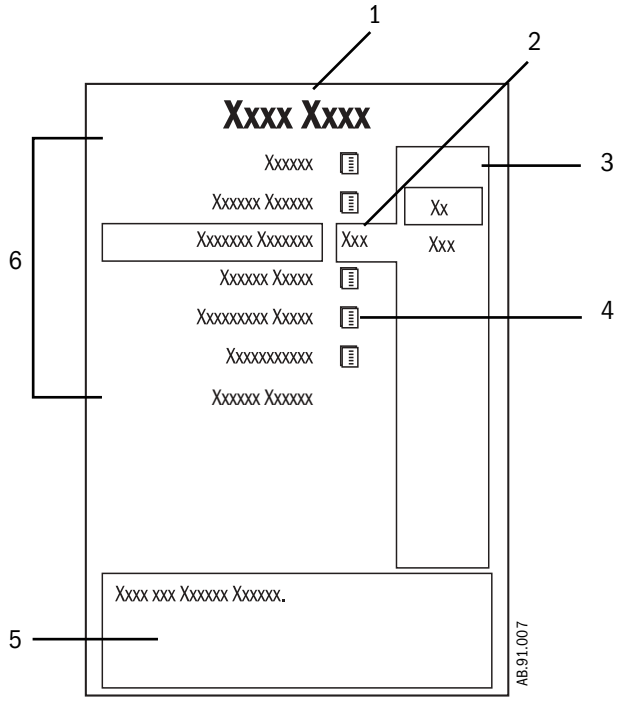
1. Menu
2. Waveform fields

Figure 1-6 • Menu view

1.6.1 Using menus

Push a menu key to display the corresponding menu. Use the ComWheel to navigate through the menu.



1. Menu title
2. Present selection
3. Adjustment window
4. Indicates submenu
5. Short instructions
6. Menu selections

Figure 1-7 • Example menu

1. Push the menu key to display the corresponding menu.
2. Turn the ComWheel counterclockwise to highlight the next menu item. (Turn the ComWheel clockwise to highlight the previous menu item.)
3. Push the ComWheel to enter the adjustment window or a submenu.
4. Turn the ComWheel clockwise or counterclockwise to highlight the desired selection.
5. Push the ComWheel to confirm the selection.
6. Select ***Normal Screen*** or push the **Normal Screen** key to exit the menu and return to the normal monitoring display. (Select ***Previous Menu*** to return to the last displayed menu, if available.)

1.7 Symbols used in the manual or on the equipment

Symbols replace words on the equipment, on the display, or in Datex-Ohmeda manuals.

Warnings and Cautions tell about the dangerous conditions that can occur if the instructions in the manual are not followed.

Warnings tell about a condition that can cause injury to the operator or the patient.

Cautions tell about a condition that can cause damage to the equipment. Read and follow all warnings and cautions.

	On (power)		Off (power)
	On for part of the equipment		Off for part of the equipment
	Standby		Type B protection against electrical shock
	Attention, refer to product instructions IEC 60601-1		Caution, ISO 7000-0434
REF	Stock number	SN	Serial number
	Direct current		Alternating current
	Earth ground		Protective earth ground
	Equipotential connector		Fuse
	Lock		Unlock
	Variability		Variability in steps
+	Plus, positive polarity	-	Minus, negative polarity
	Movement in one direction		Movement in both directions
	This way up		Warning, dangerous voltage

Pneumatic inlet

Pneumatic outlet

Electrical input

Electrical output

Inspiratory port

Expiratory port

Electrical testing certification

Inspiratory breath identifier

Serial port

Module data indicator

Module bay port

Electronic micropump nebulizer

Auxiliary pressure port

Display signal input/output

No battery/battery failure

Battery in use. Bar indicates amount of battery power remaining.

Silence alarms

Submenu

Hourmeter

Drain outlet

Air

Pump

Heavy object

USB port

Ethernet connection

Network ID connection
(Datex-Ohmeda proprietary port)

Autoclavable

Not autoclavable

Authorized representative in the European Community

Systems with this mark agree with the European Council Directive (93/42/EEC) for Medical Devices when they are used as specified in their User's Reference Manuals. The xxxx is the certification number of the Notified Body used by Datex-Ohmeda's Quality Systems.

2 Theory of Operation

In this section

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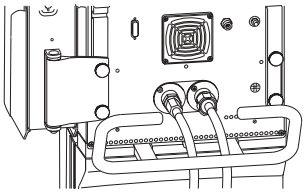
2.1 Pneumatic Operation

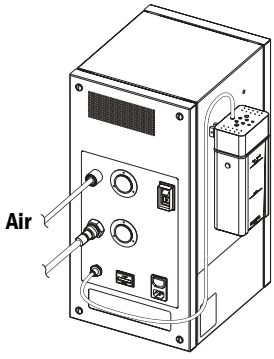
For a complete diagram of the pneumatic system, refer to Figure 11-2, "*Vent Engine manifold flow diagram*" in Section11.

The EV requires a medical-grade oxygen (O_2) and Air source ranging from 2.4 to 6.5 bar (35 to 94 psi).

The system includes two separate channels (O_2 and Air) to provide dynamic mixture control of the delivered O_2 percentage.

The Air supply may include an optional compressor unit {1} for applications where pipeline Air is not available or to provide a continued Air supply if the pipeline supply goes down.

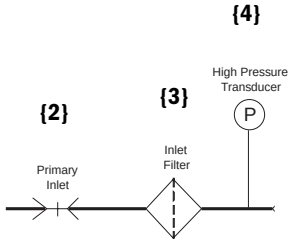




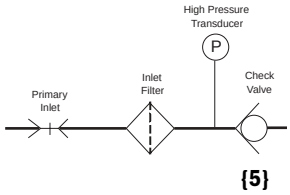
2.1.1 Inspiratory circuit

Compressed gas enters the EV through an inlet fitting {2} that is particular to the institution's supply system. The gas is filtered through a 2-micron particulate filter {3} as it enters the ventilator's "pneumatic engine" manifold.

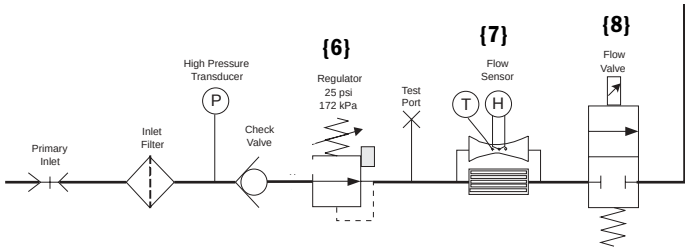
A high-pressure transducer {4} having a dynamic range of 0 to 8.3 bar (0 to 120 psi) is tapped at the outlet of the filter. This transducer monitors the adequacy of the supply pressure. Failures of supply gas, coupling hoses or an occluded filter are identified by the supply pressure transducer.



Next in the downstream path of flow is a check valve {5}. The check valve prevents backflow from the EV that would possibly contaminate the supply pressure lines. For example; if the O_2 supply were to be lost, the check valve in the O_2 channel will prevent Air from moving back into the O_2 supply lines.



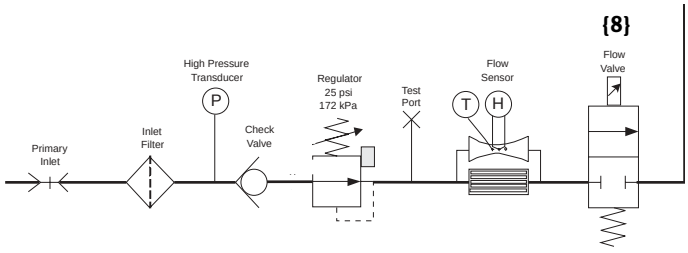
Downstream from the check valve is a 172 kPa (25 psi) pressure regulator {6}. (The regulator is a non-relieving type that does not bleed gas into the ventilator's enclosure.) The regulator ensures a constant pressure supply to the flow valve {8}. The regulated supply is flow rate dependant, which is compensated for in the flow valve's on-site calibration.



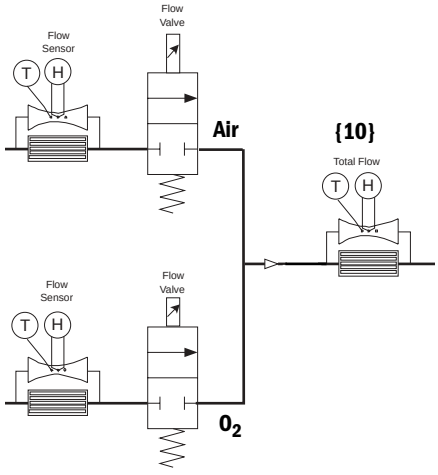
Between the regulator and the flow valves is the inspiratory flow sensor {7}. The sensor is a thermal mass-flow type that injects heat into the flow stream and monitors the associated temperature rise at a downstream location. The temperature change is dependent on the mass flow of the flow stream and the specific heat of the gas moving through the sensor. Since the composition of gas in the sensor is known, a conversion of mass-flow rate to volumetric flow at ambient conditions can be made using the ambient density of the gas. The sensor uses a laminar (two channel) flow element to split a portion of the flow through the sensor past the heat injection and temperature sensing elements. The sensor is pre-calibrated and includes an electronic PCB that produces direct digital output of mass flow through an RS-232 interface.

Individual flow sensors measure the volume of gas dispensed from the O_2 and Air channels during inspiration and expiration. The relative proportion of gas dispensed from each channel is continuously adjusted to precisely control the percentage of O_2 delivered to the patient.

Downstream of the flow sensor is a flow valve {8} that meters flows from approximately 0.05 l/min (leakage level) to a full flow value of 160 l/min. The valve is a normally- closed proportional solenoid that is powered by a current feedback loop. When calibrated on-site, using data from the inspiratory flow sensor, a precise volumetric flow versus input current profile is developed that includes both the valve and regulator characteristics.



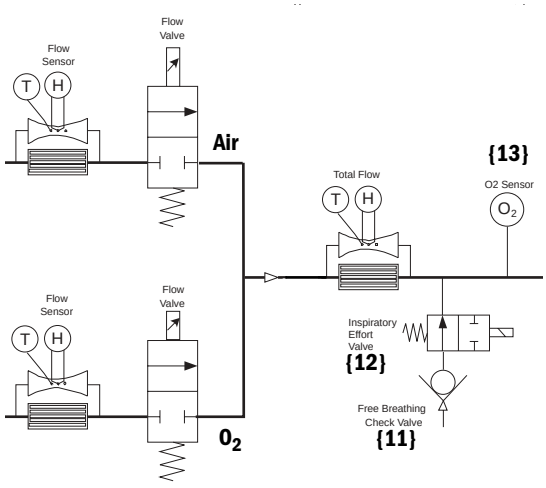
Following the two individual flow valves is the total flow sensor {10}. This sensor is the same type as the individual flow sensors and is used to measure the combined inspiratory flow being dispensed from the system. Using the known mixture composition along with atmospheric pressure and gas temperature information, mass-flow data from the sensor is converted to delivered volumetric flow towards the patient. During calibration, the sensor is checked against the output of the O_2 and Air flow sensors to ensure proper operation.



Following the total flow sensor are the free-breathing check valve {11} and the inspiratory effort valve {12}.

During normal operation, the inspiratory effort valve is open, allowing the free-breathing check valve to admit flow if the patient draws a significant amount of inspiratory pressure, causing the airway pressure to become more negative than -0.5 cm H_2O. The free-breathing check valve allows the patient to spontaneously breathe in case of a ventilation delivery failure.

On occasion, to assess the patient's tolerance to be weaned from the ventilator, clinicians can determine the amplitude of inspiratory effort that the patient can create. During this "procedure", the inspiratory effort valve is closed, effectively locking out the free breathing valve from the patient circuit.

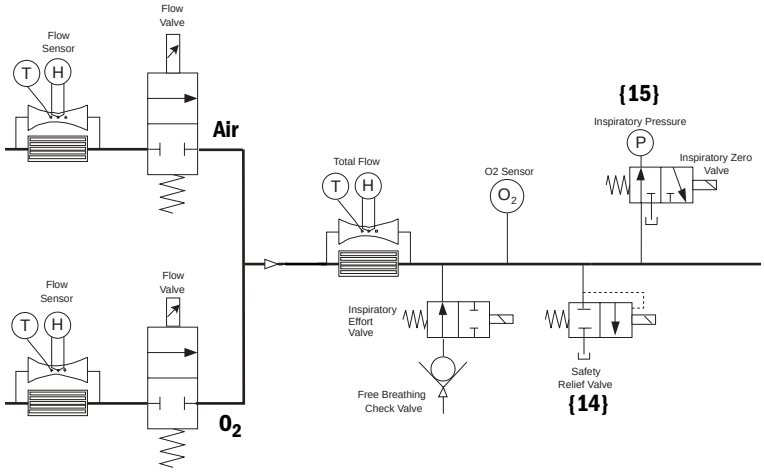


Next in the flow path is the O_2 sensor {13}. The sensor is used to monitor the O_2 concentration produced by the combined O_2 and Air flows.

The O_2 sensor uses the paramagnetic principle (oxygen molecules are attracted in magnetic fields) to measure the oxygen concentration. The sensor includes two nitrogen-filled glass spheres mounted on a suspension containing a conductive coil that is located in a non-uniform magnetic field. When the system is disturbed by an impulse of current, the suspension begins to oscillate, inducing an EMF into the coil. The oscillation period of the induced EMF is dependent on the partial pressure of oxygen surrounding the suspension.

As sample gas fills the sensor, oxygen that is present in the sample is attracted into the strongest part of the magnetic field. This congregation of O_2 molecules alters the natural oscillation frequency of the suspension. Calculations based on the difference between the oscillation period for an oxygen sample and that for nitrogen, and readings from the absolute pressure transducer, determine the measured O_2 percentage.

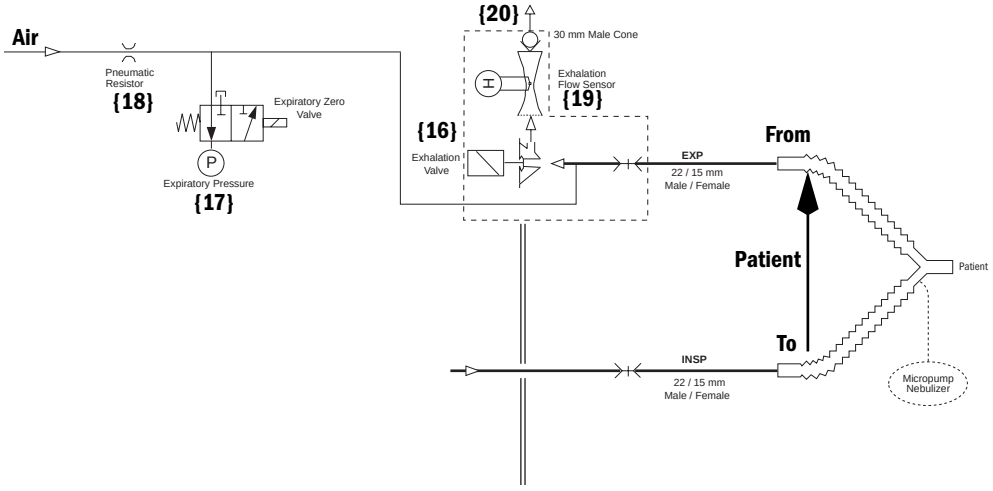
As a safety measure, a relief valve {14}, located downstream from the O_2 sensor, can be energized to vent the full flow rate of the inspiratory delivery side of the system. If an overpressure condition is detected, the valve can be opened by either of the EV's two control processors. To provide redundant safety (independent of the electronic circuits), the valve begins to mechanically relieve pressure at a nominal 115 cm H_2O.



The inspiratory airway pressure transducer {15}, along with its associated zeroing valve, is located just prior to the inspiratory outlet port. This transducer has a range of –20 to 120 cm H_2O and serves as one of three airway pressure measuring devices in the EV.

2.1.2 Expiratory circuit

At the expiratory side of the ventilator, a solenoid powered exhalation valve {16} controls exhaust from the breathing circuit. The valve contains an elastomer diaphragm that is held against a rigid seat by a solenoid (voice coil) driven piston. The valve achieves a balance between the pressure generated within its 21-mm diameter seat area and the force applied by the piston, releasing exhalation flow as necessary to maintain balance. The proportional solenoid controls the exhalation sealing pressure within a range of 0 to 100 cm H_2O. Software control provides continuous oscillatory movement (dithering) of the exhalation valve to minimize static friction effects.



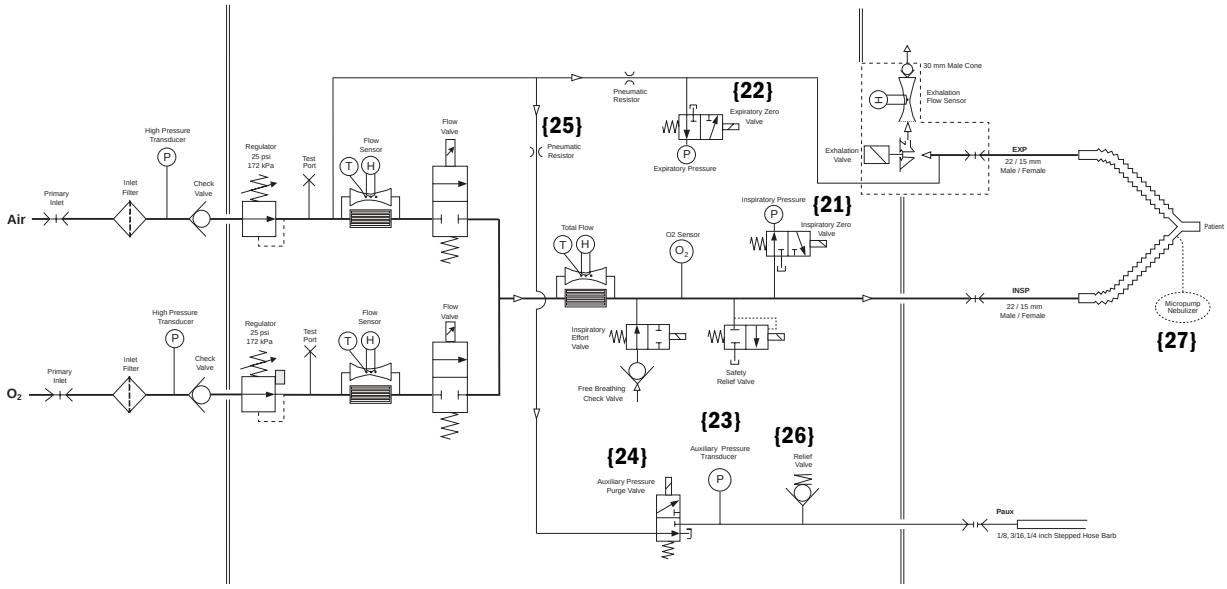
Immediately upstream of the exhalation valve is a tap for the expiratory pressure transducer {17} and its associated zeroing valve. The expiratory pressure tap is continuously purged with 35 ml/min of air to ensure that exhaled condensate does not occlude the tap. The air flow is established from the regulated Air supply using a fixed orifice (pneumatic resistor) {18}.

Downstream of the exhalation valve is the expiratory flow transducer {19}. In principle, the transducer is similar to a hot-wire anemometer. A wire having a large “temperature to electrical resistance” relationship is placed in the flowstream. The wire is kept at a constant temperature using a Wheatstone bridge circuit. The current necessary to maintain the resistance of the sensor portion of the bridge is a function of the flow through the sensor.

At the output of the flow sensor is a flapper type check valve {20} that prevents gas from being drawn in through the expiratory valve and minimizes patient rebreathing in the event of a ventilator failure.

2.1.3 Associated circuits

Associated with the inspiratory and expiratory pressure transducers are two “zeroing” solenoid valves {21} and {22}. These valves are used to disconnect the pressure transducers from circuit pressure and vent them to atmosphere during zero bias calibration. This zeroing procedure is conducted routinely (every 12 hours) under the control of the Vent Engine software.



A third (auxiliary) pressure channel {23} is used to measure additional patient “airway” pressures at the discretion of the clinician. This port could be used to measure circuit pressure directly at the airway, laryngeal cuff pressures or pressures lower in the airway tract. The transducer circuit includes a valve {24} to provide a 35 ml/min purge flow as required by the particular clinical application. For example, in measuring airway pressure at the endotracheal tube the purge would most likely be turned on, but for measuring laryngeal cuff pressures (closed system) the purge would be turned off. The purge flow is established from the regulated Air supply using a fixed orifice (pneumatic resistor) {25}. The relief valve {26} limits pressure in the auxiliary channel to less than 230 cm H_2O.

2.1.4 Electronic micropump nebulizer

The Aeroneb Professional Nebulizer System (Aeroneb Pro) by Aerogen, Inc. {27} is integrated into the EV. This nebulizer is electrically connected to the EV and uses proprietary technology to produce a fine-droplet, low-velocity aerosolized drug delivered into the breathing circuit.

The Aeroneb Pro is designed to operate in-line with standard ventilator circuits and mechanical ventilators. It operates without changing the patient ventilator parameters.

2.2 Electrical Operation

For a complete diagram of the electrical system, refer to Figure 11-4, "*Electrical architecture*" in Section11.

The EV includes 4 major processor control boards:

- the Display Unit (DU),
- the Ventilator Control Board (VCB),
- the Ventilation Monitoring Board (VMB),
- and the Power Management Board (PMB).

Two analog boards — the motherboard (backplane) and the monitoring module power supply board — round out the electronic architecture.

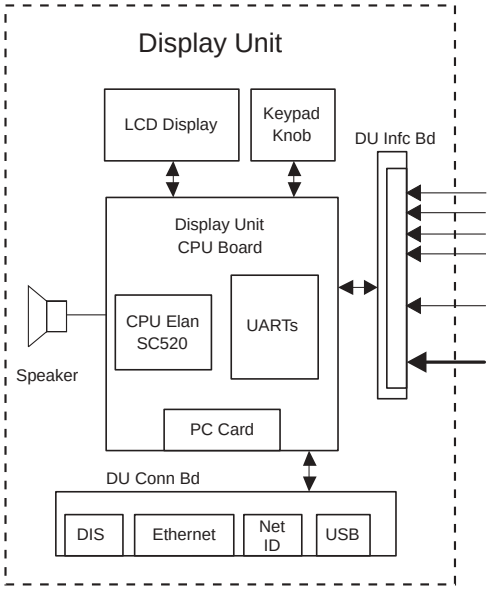
2.2.1 Display Unit (DU)

The DU is physically separate from the ventilator chassis (connected through a single cable running through the display arm). The DU contains a CPU board based on the Elan SC520 processor. A small daughter board (DU Interface board), provides a communications interface between the DU's CPU and the remainder of the EV system. A second daughter board (DU Connector board), provides hardware connector interfaces for the USB , Network ID, Ethernet, and **DIS** (Display Interface Solution) ports.

The CPU board includes a PCMCIA (PC Card) interface.

The DU's CPU board provides power and signals for operating the main audio speaker and a 12 inch (30 cm) backlit color LCD display, providing an interactive video interface. Membrane keys from three front-panel keypads and a rotary encoder (ComWheel) complete the loop for acquiring user inputs.

The DU housing contains a continuously operating fan for temperature reduction.



2.2.2 Communication channels

The DU communicates to the remainder of the EV system through the motherboard using 5 digital channels.

[1] A 500 Kbaud, RS-485 interface (Mod Bus: Datex-Ohmeda proprietary module communication protocol), to external monitoring modules. This link runs through the Monitoring Module Power supply board which forms the physical interface to the M-Gas (and ultimately other) monitoring modules.

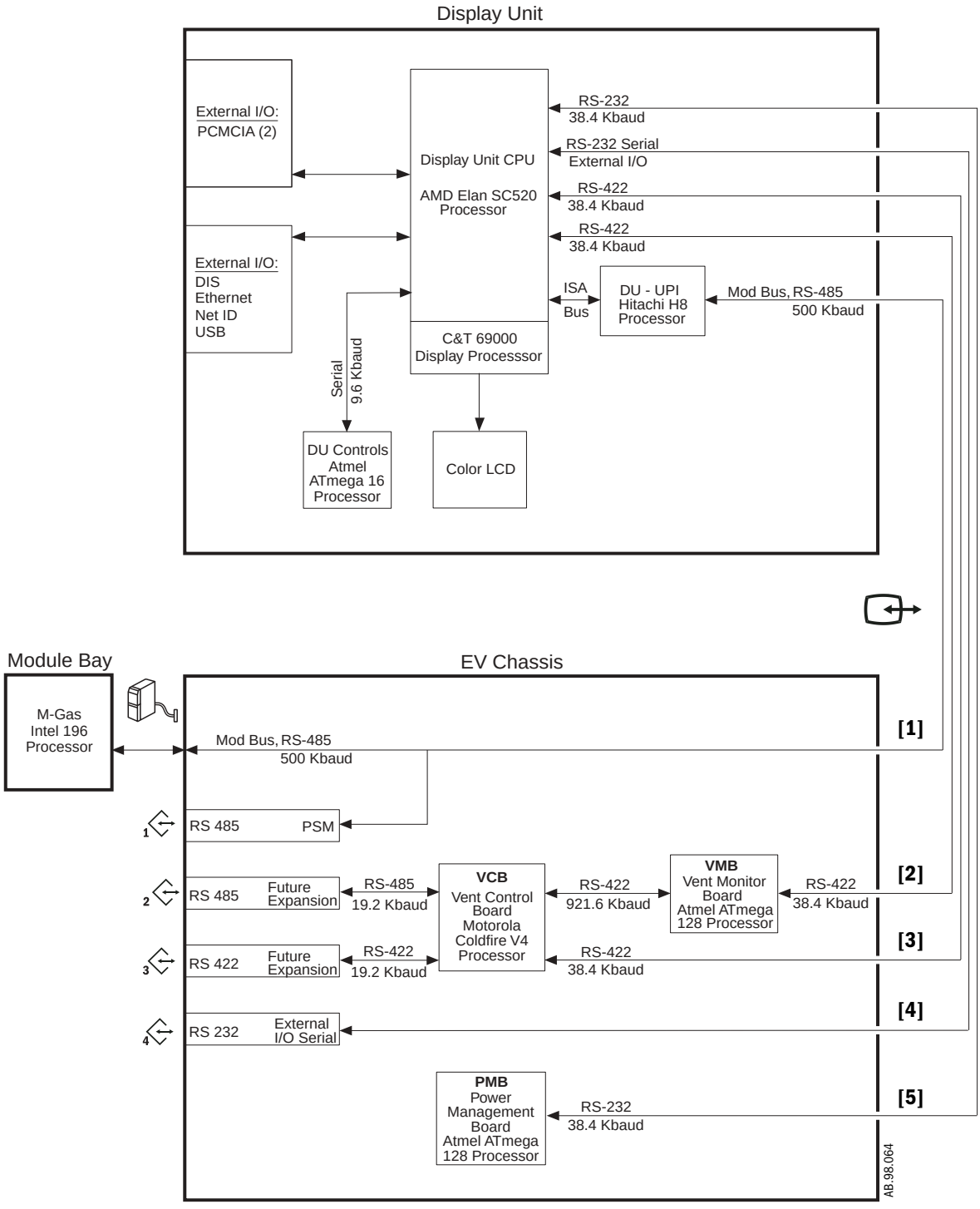
Additionally, the Mod Bus interfaces with the PSM (Patient Side Module) support circuitry (future expansion).

[2] A 38.4 Kbaud, RS-422 interface relays setting and alarm annunciation information from the VMB, and receives alarm commands and data.

[3] A 38.4 Kbaud, RS-422 interface relays setting and alarm annunciation information from the VCB, and receives sensor data for presentation to the user as well as alarm commands. As described later, the VMB also communicates directly to the VCB, thus there exists a triangle of bi-directional communication paths between the DU, VCB and VMB.

[4] An RS-232 Serial port that routes to an external connector directly on the motherboard. This link ports data from the DU to other compatible equipment via the Ohmeda Com 1 protocol.

[5] A 38.4 Kbaud, RS-232 link to the PMB. Aside from providing battery and power information to the DU, this link is used to confirm a “hard” power down of the EV with user inputs to the DU being relayed to the PMB for power down action.


Display Unit
External I/O:
PCMCIA (2)
External I/O:
DIS
Ethernet
Net ID
USB
Display Unit CPU
AMD Elan SC520
Processor
C&T 69000
Display Processsor
Serial
9.6 Kbaud
DU Controls
Atmel
ATmega 16
Processor
Color LCD
ISA
Bus
DU - UPI
Hitachi H8
Processor
RS-232
38.4 Kbaud
RS-232 Serial
External I/O
RS-422
38.4 Kbaud
RS-422
38.4 Kbaud
Mod Bus, RS-485
500 Kbaud
Module Bay
M-Gas
Intel 196
Processor
EV Chassis
Mod Bus, RS-485
500 Kbaud
[1]
1
RS 485
PSM
2
RS 485
Future
Expansion
RS-485
19.2 Kbaud
VCB
Vent Control
Board
Motorola
Coldfire V4
Processor
RS-422
921.6 Kbaud
VMB
Vent Monitor
Board
Atmel ATmega
128 Processor
RS-422
38.4 Kbaud
[2]
3
RS 422
Future
Expansion
RS-422
19.2 Kbaud
RS-422
38.4 Kbaud
[3]
4
RS 232
External
I/O Serial
[4]
PMB
Power
Management
Board
Atmel ATmega
128 Processor
RS-232
38.4 Kbaud
[5]
AB.98.064

2.2.3 Ventilator Control Board - VCB

The VCB is a Motorola Coldfire V4 CPU powered assembly that:

- collects information from all EV system sensors (some indirectly from the VMB),
- and controls all actuators necessary to effect ventilation delivery.

The VCB computes and supplies all ventilation sensor monitoring data for display on the DU. If there are alarms to be generated based on this monitoring data, the VCB notifies the DU to post the appropriate alarm message and audio sequence. The VCB observes the DU's response to ensure that the alarm is adequately presented.

To control ventilation, the VCB accepts ventilation parameters from the DU. Measured data (waveform and numeric) is also sent to the DU from the VCB. This data flow occurs on the 38.4 Kbaud, RS-422 communications link (VCB - DU Data I/O).

The VCB also communicates directly with the VMB every 1 ms, receiving expiratory flow, expiratory pressure and O_2 sensor data on the 921.6 Kbaud, RS-422 interface (VMB Sensor Data I/O). Barometric pressure data is also received from the VMB, but at a lower data rate.

The following sensor information is acquired directly by the VCB:

- Air Flow/Temp sensor through the RS-232 cable interface @ 200 Hz,
- O2 Flow/Temp sensor through the RS-232 cable interface @ 200 Hz,
- Total Flow/Temp sensor through the RS-232 cable interface @ 200 Hz,
- Inspiratory Pressure sensor via a differential analog signal – 12 bits @ 1000 Hz.
- Auxiliary Pressure sensor via a differential analog signal – 12 bits @ 1000 Hz.

The VCB contains actuator drive circuits for the following:

- the Air and O2 Flow Valves,
- the Exhalation Valve,
- the Inspiratory Pressure Sensor zeroing valve
- and the Auxiliary Pressure Sensor purge flow valve.

All valve actuators are driven using current drive circuits and feedback controlled using current sense resistors. The VCB contains digital control signals for activating the inspiratory effort and safety relief valves (through the VMB) and the Piezo-Electric Nebulizer.

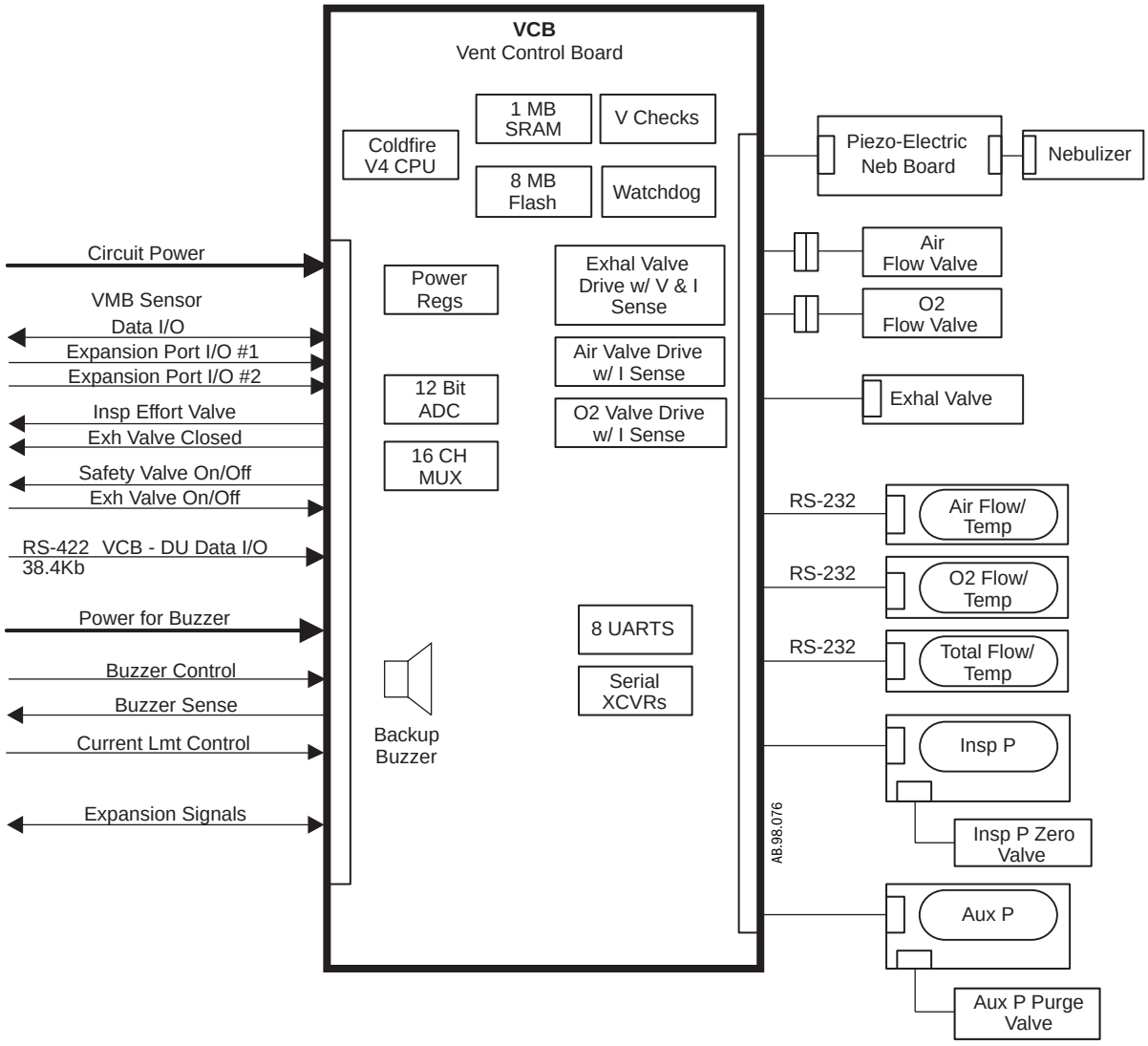
The VCB receives 12.5 Vdc from the PMB, which it regulates down to various voltages for use by the board's digital circuits and analog drivers. These voltage levels are self-tested on the VCB.

An additional 12.5 Vdc power line is separately connected to an auxiliary buzzer on the VCB that provides a backup audio alarm source. The buzzer is normally on and must be kept silent by both the VCB and through a dedicated digital line coming from the VMB. A reset or failure of either the VCB or VMB is regarded as a system fault and the buzzer is activated.

The VCB includes 1 MB of SRAM and 8 MB of Flash memory. The CPU is connected to a digital watchdog circuit to monitor continuous and properly sequenced execution of software code.

As the core processor unit for the EV, the VCB includes two external serial I/O channels: one 19.2 Kbaud RS-422 channel (Expansion Port I/O #1 to External Connector 3) and one 500 Kbaud RS-485 channel (Expansion Port I/O #2 to External Connector 2).

For further details, refer to Figure 11-9, "*VCB block diagram*" in Section11.



2.2.4 Ventilator Monitoring Board - VMB

The VMB is based on an Atmel Atmega 128 CPU. The VMB performs as an independent monitoring system that provides computational and oversight redundancy to the DU and VCB.

The VMB independently acquires sensor data relating to the ventilator's three safety parameters:

- airway pressure (expiratory),
- delivered O_2 percentage,
- and exhaled minute/tidal volume.

In addition, the VMB monitors the air and oxygen supply pressures:

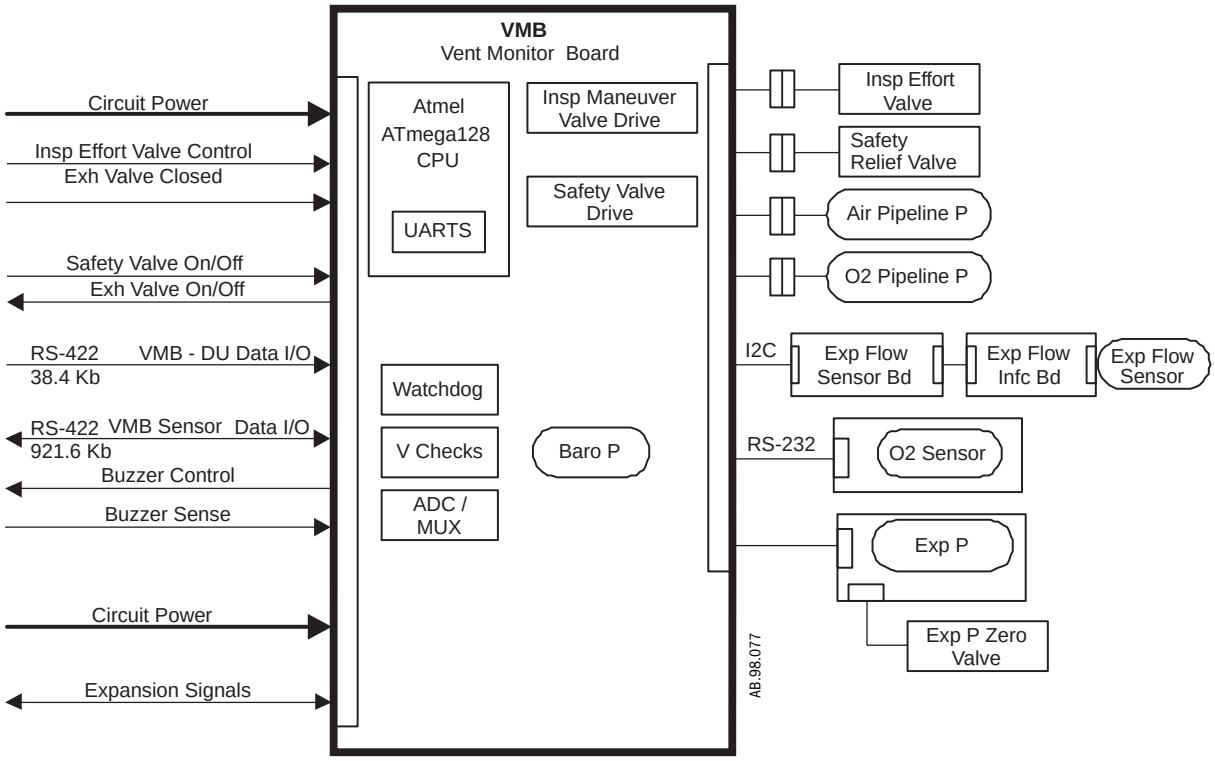
- Air High Pressure Supply via analog cable –10 bits @ 11 Hz,
- O2 High Pressure Supply via analog cable – 10 bits @ 11 Hz,
- Expiratory flow sensor data via an I^2C cable interface @ 200 Hz,
- O_2 Concentration via a serial cable @ 5 Hz,
- Expiratory Airway Pressure via analog signal – 12 bits @ 1000 Hz,
- Barometric Pressure onboard VMB – 10 bits @ 11 Hz.

The VMB controls a safety valve actuator that enables it to unilaterally relieve pressure in the breathing circuit. This allows the barotrauma hazard with its 50 ms reaction time to be independently controlled by either action of the VCB or VMB. The hazards associated with O_2 concentration (improper mixture) and low exhaled minute volume (hypoventilation) have much slower reaction times (on the order of minutes) and are controlled under fault conditions by the VMB's ability to unilaterally activate the backup buzzer.

The VMB receives 12.5 Vdc from the PMB, which it regulates down to various voltages for use by the board's digital circuits and analog drivers. These voltage levels are self-tested on the VMB.

The VMB communicates directly to the DU via the bi-directional 38.4 Kbaud RS-422 channel (VCD - DU Data I/O). A separate 921.6 Kb RS-422 link (VMB Sensor Data I/O) is used to transmit the VMB's sensor data to the VCB.

For further details, refer to Figure 11-8, "*VMB block diagram*" in Section11.



2.2.5 Power Management Board – PMB

The PMB is based on an Atmel Atmega 128 CPU. The PMB performs power selection between power sources in the following order:

- AC power mains,
- External battery,
- Internal battery.

The PMB regulates the 24 Vdc power supply output down to raw 16 V and 12.5 V power rails that are used throughout the system (all boards locally regulate from these power rails).

The PMB controls the charging operation of the internal battery, selecting trickle, bulk, or float charge status.

The PMB communicates with the DU through the 9.6 Kbaud, RS-232 link (PMB Data I/O). It sends status commands to the DU concerning the charge status of the internal 24 V battery.

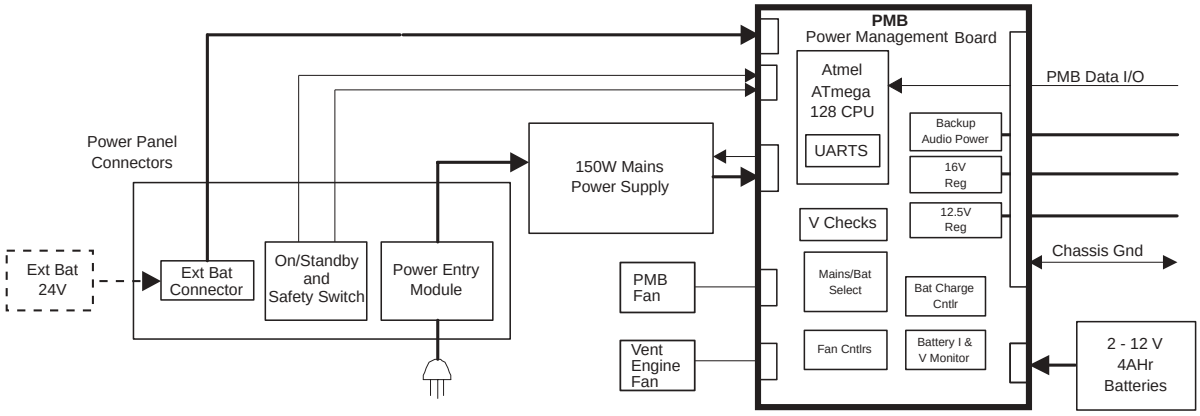
The PMB uses this link as a communication interlock to handle the unit shutdown sequence. Once a signal is received by the PMB from the mechanical On/Standby switch, the PMB prompts the DU for a confirmation signal that shutdown is appropriate (unit is not in a ventilation therapy state). Once the DU relays this confirmation to the PMB, the power-off sequence is initiated.

The PMB supports the operation of the EV chassis fan and the fan on the PMB heatsink.

2.2.6 Other Electronic Items

The EV/5 employs a separate AC to DC switching power supply for the providing a nominal 24v voltage level to the PMB. The power supply is capable of regulating 150 W of power output. A power entry module contains fuses and filters for Mains AC input cables. Finally, two internal 12v batteries are connected in series to provide an internal backup 24v power source for the system.

For further details, refer to Figure 11-7, "*PMB block diagram*" in Section11.



2.2.7 Motherboard (backplane)

The EV motherboard provides backplane connectivity for the VCB, VMB and PMB assemblies in the EV chassis.

Analog circuits on the board provide current limiting for external peripheral connections to ensure that the EV's primary ventilation and monitoring functions are not compromised by excessive power draw. In addition, 10VA energy limit circuitry is provided for power connections within 20 cm of O_2 exhaust outlets, in order to mitigate the risk of an oxygen enriched fire.

The board features 6 external connectors that exit through a rear sheet metal interface:

- Patient Side Module (PSM) support connector (future expansion)

- RS-485 Serial (future expansion) connector

- RS-422 Serial (future expansion) connector

- External Serial I/O connector

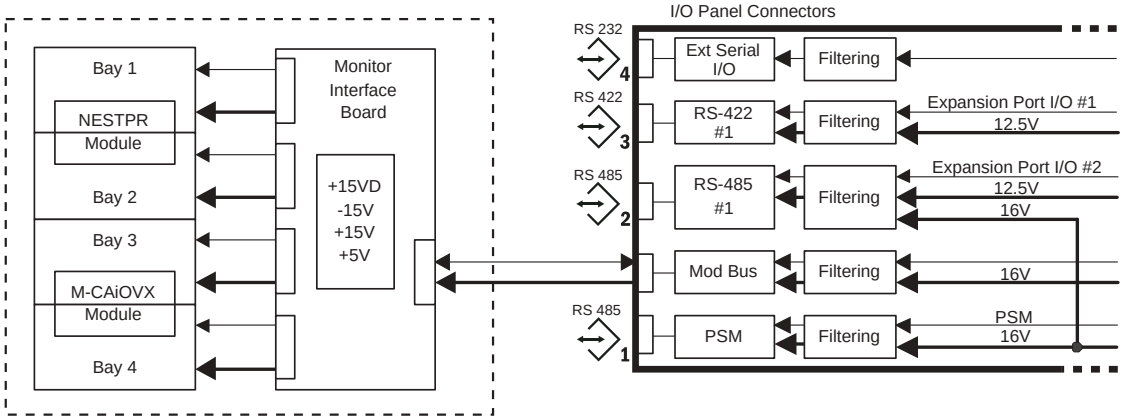
- Main DU connector (communication channel between DU and EV)

- Monitoring Module, Mod Bus connector

2.2.8 Monitoring Interface Board – Monitoring Module Bays

The EV accommodates an optional four-bay module assembly that supports compatible Datex-Ohmeda M-series modules.

The assembly includes a Monitoring Interface Board (MIB) that communicates with the DU through the Mod Bus connector. The MIB includes circuitry that regulates the raw16 V power down to +15 V (unregulated), ±15 V (regulated), and +5 V levels required by the M series monitoring modules.



Notes

3 Checkout Procedure

In this section

3.1 Inspect the system 3-2
3.2 Automated Checkout 3-2
3.3 Backlight test 3-3
3.4 Power failure test 3-3
3.5 Electrical safety tests 3-3

⚠ WARNINGS After any repair or service of the Engström Ventilator, complete all tests in this section.

Before you do the tests in this section:

- Complete all necessary calibrations and subassembly tests. Refer to the individual procedures for a list of necessary calibrations.
- Completely reassemble the system.

If a test failure occurs, make appropriate repairs and test for correct operation.

3.1 Inspect the system

Before testing the system, ensure that:

- The equipment is not damaged.
- Components are correctly attached.
- Pipeline gas supplies are connected.
- The casters are not loose and the brakes are set and prevent movement.
- The power cord is connected to a wall outlet. The mains indicator comes on when AC Power is connected.

3.2 Automated Checkout

The EV is equipped with an automated checkout.

When in Standby, the ***Patient Setup*** menu is displayed on the normal screen.

1. Select ***Checkout***.
2. Attach the patient circuit.
3. Occlude the patient wye.
4. Select ***Start Check***.
   - The results appear next to each check as they are completed. When the entire checkout is finished 'Checkout complete' will appear and the highlight will move to ***Delete Trends***.
   - If one or more checks fail, select ***Check Help*** for troubleshooting tips.
5. Select ***Previous Menu***.

Checkout includes the following checks:

- Paw Transducer Check
- Barometric Pressure Check
- Relief Valve Check
- Exhalation Valve Check
- Expiratory Flow Sensor Check
- Air Flow Sensor Check
- O2 Flow Sensor Check
- O2 Concentration Sensor Check
- Circuit Leak, Compliance, and Resistance

Note If any of the Checks fail, refer to Section 7.1, "Troubleshooting Checkout Failures", to troubleshoot a specific failure.

3.3 Backlight test

1. Access the Calibration menu.
   - In the standby mode, push the **System Setup** key.
   - On the System Setup menu, select ***Install/Service*** (23-17-21).
   - On the Install/Service menu, select ***Calibration***.
2. On the Calibration menu, select ***Backlight Test***.
3. Select ***Start Test***.
4. The display will show the test running on light 1 and then on light 2. If the display goes completely blank or flickers during the test, one of the lights has failed.

3.4 Power failure test

1. Connect the power cord to a wall outlet. The mains indicator on the front panel of the Display Unit comes on when AC Power is connected.
2. Set the system switch to On and Start a case.
3. Unplug the power cord with the system turned on.
4. Make sure that the power failure alarm comes on.
5. Make sure the following message is displayed:
   - 'On battery'
6. Connect the power cable again.
7. Make sure the alarm cancels.

3.5 Electrical safety tests

⚠ **WARNING** Make sure the system is completely assembled and that the power cords are connected as illustrated in Section 10.12. Make sure all accessory devices are connected to electrical outlets.

1. Connect an approved test device (for example: UL, CSA, or AAMI) and verify that the leakage current is less than:

Voltage	Max. Leakage Current
120/100 Vac	300 μAmps
220/240 Vac	500 μAmps

2. Make sure that the resistance to ground is less than 0.2Ω between the equipotential stud and the ground pin on the power cord.

Notes

4 Installation and Service Menus

In this section

4.1 Service and Installation menu structure 4-2

4.2 Install/Service Menu (Super User) 4-3

4.2.1 Defaults 4-4

4.2.2 Factory Defaults 4-5

4.3 Calibration menu 4-6

4.4 Service menu 4-7

4.4.1 Configuration 4-8

4.4.2 Copy Configuration 4-9

4.4.3 Service Log menu 4-10

4.4.4 Software/Hardware version menu 4-11

4.1 Service and Installation menu structure

This section describes the Service level functions that are part of the main software installed in the ventilator.

Section 8, "*Service Diagnostics and Software Download*," covers a separate service application that loads from a PCMCIA card and is used to download system software and run service diagnostics and other service tests.

Menu structure

The Service menu structure has two levels which are password protected:

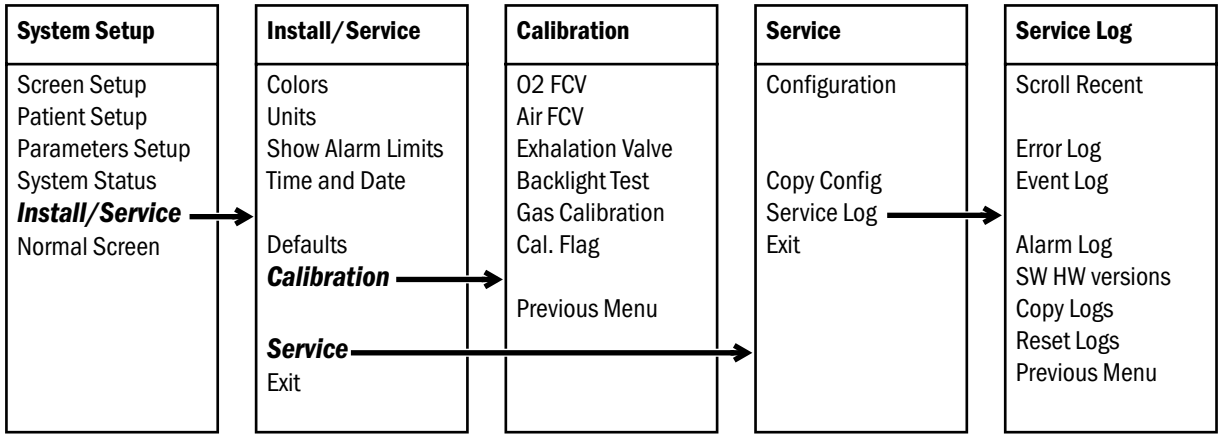
- Install/Service (super-user)
- Service

The **Install/Service** level (with super-user password) supports standard hospital preferences such as colors, units, ventilator settings and alarm defaults, and access to the **Calibration** and **Service** menus.

The **Service** level (with service password) supports system configuration and provides access to the Service Log menu.

Follow the menu structure to access the various service screens:

- on the front panel of the Display Unit, press the **System Setup** key to access the System Setup menu.
- on the **System Setup** menu, select **Install/Service** to access (with super-user password) the Install/Service menu;
  - select **Calibration** to access the Calibration menu.
  - select **Service** to access (with service password) the Service menus.



4.2 Install/Service Menu (Super User)

Use the super-user password to access the Install/Service menu: "23-17-21".

Menu Item	Message text	Comments
Colors	Set colors of parameters.	Change color of waveform, digits, and trend for Paw, Flow, O2, CO2, Volume, and Paux. (Yellow, White, Green, Red, and Blue)
Units	Set units of Paw, flow, CO2, height, weight, and gas supply pressure. **EXIT:** (Turn power off to exit menu.)	Paw — kPa, hPa, cmH2O, mmHg, mbar Flow — l/min, l/s CO2 — %, kPa, mmHg Height — cm, ft Weight — kg, lb Gas Supply Pressure — psi, kPa, bar
Show Alarm Limits	Select Yes to show alarm limits in digit fields.	Default is Yes
Time and Date	Change clock and calendar functions.	
Defaults	Set or change default settings.	Refer to section 4.2.1
Calibration	Calibrate airway gas and test backlights.	Refer to section 4.3
Service	Show technical data for troubleshooting and calibration.	Refer to section 4.4
Exit	Turn power off to exit menu.	

4.2.1 Defaults

Menu Item	Message text	Comments
Scroll Settings	Push ComWheel to scroll default settings.	
Default Type	Select default patient type.	The selected type (Adult or Pediatric) determines the Patient Type in the Patient Setup Menu on power up. The corresponding Adult or Pediatric facility defaults are displayed for the settings on power up. If the setting is changed within a power cycle, those settings remain for a specific Patient Type until they are changed by the user or the ventilator is turned off.
View		Not selectable: Heading for the following mutually exclusive lists — Adult, Pediatric, Factory.
Adult	Show Adult defaults and settings.	The “Adult Settings” page contains a list of parameters or settings and the corresponding “Saved” and “Current” values for the Adult patient type. The “Current” values reflect the settings in the Vent Setup and Alarms Setup menus. Any setting that does not have a value shows three dashes.
Pediatric	Show Pediatric defaults and settings.	The “Pediatric Settings” page contains a list of parameters or settings and the corresponding “Saved” and “Current” values for the Pediatric patient type. The “Current” values reflect the settings in the Vent Setup and Alarms Setup menus. Any setting that does not have a value shows three dashes.
Factory	Show Factory defaults.	Refer to section 4.2.2
Backup	Set defaults for backup ventilation.	
Save Current	Save current settings as facility defaults.	The default selection is No. Common values in the saved defaults are overridden if another ventilation mode is set up and saved.
Save Factory	Save factory settings as facility defaults.	The default selection is No. If Yes is selected, “Reset machine for defaults to take effect.”
Previous Menu	Return to previous menu.	

4.2.2 Factory Defaults

The following table lists the factory defaults for parameters and alarm limits:

Setting	Adult	Pediatric	Backup Defaults
Vent Mode	BiLevel	BiLevel	PCV
FiO2	50	50	Current FiO2 setting
TV	500	100	
Pinsp	10 cmH2O (10 mbar, 1.0 kPa, 10 hPa, 8 mmHg)	7 cmH2O (7 mbar, 0.7 kPa, 7 hPa, 5 mmHg)	10 cmH2O (10 mbar, 1.0 kPa, 10 hPa, 8 mmHg)
Rate	10	16	12
I:E	1:2	1:2	1:2
Tinsp	1.70	1.0	
PEEP	Off	Off	Off
Psupp	5 cmH2O (5 mbar, 0.5 kPa, 5 hPa, 4 mmHg)	3 cmH2O (3 mbar, 0.3 kPa, 3 hPa, 2 mmHg)	
Pmax	30 cmH2O (30 mbar, 3 kPa, 30 hPa, 23 mmHg)	30 cmH2O (30 mbar, 3 kPa, 30 hPa, 23 mmHg)	40 cmH2O (40 mbar, 4 kPa, 40 hPa, 29 mmHg)
Plimit	20 cmH2O (20 mbar, 2 kPa, 20 hPa, 15 mmHg)	20 cmH2O (20 mbar, 2 kPa, 20 hPa, 15 mmHg)	
Insp Pause	0	0	
Rise Time	100 ms	100 ms	100 ms
Trig Window	25	25	
Trigger	2 l/min (0.03 l/s)	1 l/min (0.02 l/s)	2 l/min (0.03 l/s)
Bias Flow	3 l/min (0.05 l/s)	2 l/min (0.04 l/s)	3 l/min (0.05 l/s)
End Flow	25	25	
Low FiO2	44	44	
High FiO2	56	56	
Low MVexp	2 l/min (0.03 l/s)	1 l/min (0.02 l/s)	
High MVexp	10 l/min (0.16 l/s)	5 l/min (0.08 l/s)	
Low TVexp	Off	Off	
High TVexp	Off	Off	
Low RR	Off	Off	
High RR	Off	Off	
Low EtO2	Off	Off	
High EtO2	Off	Off	
Low EtCO2	3% (3 kPa, 23 mmHg)	3% (3 kPa, 23 mmHg)	
High EtCO2	8% (8 kPa, 60 mmHg)	8% (8 kPa, 60 mmHg)	
Wave Field 3	Vol (Volume)	Vol (Volume)	
Digit Field	Compl (Pulmonary Mechanics)	Compl (Pulmonary Mechanics)	
Split Screen	None	None	
Alarm Volume	3	3	

4.3 Calibration menu

Menu Item	Message text	Comments
O2 FCV	Start O2 Flow Control Valve calibration and leak test.	
Air FCV	Start Air Flow Control Valve calibration and leak test.	
Exhalation Valve	Patient must not be connected to circuit during calibration. Start Exhalation Valve calibration.	
Backlight Test	Start display backlight test.	
Gas Calibration	Start gas calibration. Calibrate CO2 and O2 measurements.	Gas Calibration is enabled whenever an MGAS module is installed. Gas Calibration is disabled if the MGAS module is warming up.
Cal. Flag	Turn the Calibration required message On/Off.	When Cal. Flag is set to On, the “Calibration required” message is displayed in the general message area.
Previous Menu	Return to previous menu.	

Note The ***Cal. Flag*** menu item is used by the factory to activate the “Calibration required” alarm. It is set as a reminder that calibrations must be performed when the machine is set up for operation at its permanent location.

After completing the ***O2 FCV***, ***Air FCV***, and the ***Exhalation Valve*** calibrations, set the ***Cal. Flag*** to Off.

4.4 Service menu

Use the service-level password to access the Service menu:
"34-22-14."

Whenever service menu is entered, "Enter Service dd-mmm-yyyy hh:mm:ss" is recorded in the Event log.

Menu Item	Message text
Configuration	Set language, altitude and units.
Copy Config	Save or install configuration and default settings using memory card.
Service Log	Show error, event, and alarm histories and system information.
Exit	Turn power off to exit menu.

4.4.1 Configuration

Menu Item	Message text	Values	Comments
Decimal Marker	Select decimal delineator.	0.01, 0 01 or 0,01	Default: 0.01
Language	Select language for screen.	Chinese (simplified), Czech, Danish, Dutch, English, Finnish, French, German, Greek, Hungarian, Italian, Japanese, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish, Turkish	Default: English
Paw	Change Paw units: kPa, cmH2O, mbar.	kPa, cmH2O, or mbar	Default: cmH2O
Flow	Change flow units: l/min or l/s.	l/min or l/s	Default: l/min
CO2	Change CO2 units: %, kPa, or mmHg.	%, kPa, or mmHg	Default: %
Height	Change height units: cm or ft.	cm or ft	Default: cm
Weight	Change weight units: kg or lb.	kg or lb	Default: kg
Altitude	Change altitude used for gas calculations.	–400 to 3000 m in 100-m increments	Default: 300 m

4.4.2 Copy Configuration

Copy Configuration menu

Menu Item	Message text	Values	Comments
Save to Card	Save Configuration and defaults to card.	<blank>, Fail, or OK. The field is blank until the data has either been written to the card (OK) or the system determines it cannot write to the card (Fail).	Saves all settings that are not hardware dependent, including facility defaults, screen configuration, trend settings, colors, units, decimal marker, altitude, patient type, backup settings, and the Show Alarm Limits selection.
Copy from Card	Copy Configuration and defaults from card. When completed: Copy from card complete. Please reboot system.	<blank>, Fail, or OK. The field is blank until the data has either been read from the card (OK) or the system determines it cannot read the card or the card does not have the required data (Fail).	

Systems cannot accept configuration files from a different product model.

The software version is stored with the saved configuration. A system will reject any configurations from other than the current version of software.

Selecting Save to Card overwrites any configuration on the card.

4.4.3 Service Log menu

The Service log menu is a organized listing of stored events.

Menu Item	Message text
Scroll Recent	Scroll through newest entries.
Error Log	Show error history.
Event Log	Show event history.
Alarm Log	Show alarm history.
SW HW versions	Show system information.
Copy Logs	Save HW/SW info and all logs to memory card.
Reset Logs	Erase Error and Alarm log entries
Previous Menu	Return to previous menu.

Each history log shows at the top of the screen total Running Hours, the date when the logs were last reset, and the Ventilator Serial Number.

Whenever logs are reset, “Reset Logs dd-MMM-yyy hh:mm:ss” is recorded in the Event log.

If the logs are saved to a memory card, the ventilator’s serial number, date, and time are saved along with the current contents of the logs.

Error Log ◂ The Error Log lists the last 200 errors logged since the last log reset, starting with the most recent. The system stores the last 1,000 errors logged since the last log reset.

Event Log ◂ The Event Log records the service history of the device. This includes: service calibrations, entry into the service mode, options enabled, and software installation. In the event of a board replacement, it is understood that this log like all others could be lost.

The Event History menu lists the last 200 events logged starting with the most recent. The Event History log stores the last 1000 events.

The Event History log cannot be reset.

Alarm Log ◂ The Alarm Log lists the last 200 alarms since the last log reset starting with the most recent. The Alarm History log store the last 1000 entries.

Copy Logs The Copy Logs function copies Error, Event, and Alarm logs along with the software/hardware configuration to a text file on a PCMCIA card.

4.4.4 Software/ Hardware version menu

Turn the ComWheel to scroll through the list box.

Push the ComWheel to return to the Service menu.

System Information menu

X=Number, A, B, C = letter

SW HW version System Information:
Running Hours: XXXXX
Software Release: XX.XX
Model Code: XXX
Serial Number: ABCDXXXXX
Option Package: XXX
Options Code: XXXXXXXXXXXXXXX
VCB Software Version: XX.XX
VCB Hardware Version: XXXX-XXXX-XXX REV A
VCB Hardware Serial Number: ABCXXXXX
DU Software Version: XX.XX
DU Hardware Version: XXXX-XXXX-XXX REV A
DU Hardware Serial Number: ABCXXXXX
VMB Software Version: XX.XX
VMB Hardware Version: XXXX-XXXX-XXX REV A
VMB Hardware Serial Number: ABCXXXXX
PMB Software Version: XX.XX
PMB Hardware Version: XXXX-XXXX-XXX REV A
PMB Hardware Serial Number: ABCXXXXX
MGAS Software Version: X.X
MGAS Hardware Version: GAS SW Pr. XXXXXXX-X
MGAS Hardware Serial Number: ABCXXXXX

The MGAS information is only displayed when an Airway module is present.

Notes

5 Service Tests and Calibration

⚠ **WARNING** After adjustments and calibration are completed, always perform the checkout procedure. Refer to Section 3 of this manual.

In this section

5.1 Calibration (super-user) 5-2
5.1.1 Calibration procedure 5-3
5.2 Service level tests and calibration 5-4
5.2.1 Service application setup 5-4
5.2.2 Test setup 5-4
5.2.3 Vent engine debris clean-out 5-5
5.2.4 Vent engine leak test (low pressure) 5-6
5.2.5 Vent engine leak test (high O_2 pressure) 5-8
5.2.6 Vent engine leak test (high Air pressure) 5-10
5.2.7 Calibrate airway pressure transducer Zero and Span 5-12
5.2.8 Verify operation of free- breathing valve 5-14
5.2.9 Verify operation of inspiratory effort valve 5-16
5.2.10 Verify operation of auxiliary pressure relief valve 5-18
5.2.11 Mechanical over-pressure valve test 5-20
5.2.12 Verify regulator output pressure. 5-22

5.1 Calibration (super-user)

The EV ventilator includes integrated software that allows a qualified user to periodically calibrate the O_2 flow valve, the Air flow valves, and the Exhalation valve.

At a minimum, these calibrations should be completed every 12 months or when associated components are serviced or replaced. These calibrations can be performed more frequently, as needed, for optimal performance.

The menu structure for accessing the calibration software is described in Section 4, "*Installation and Service Menus*" .

Note The Valve calibrations (Section 5.1.1) can be performed without performing the Service level test and calibrations (Section 5.2). However, if the Service level test and calibrations are performed, the Valve calibrations should be performed again after the Service level test are competed (passed).

5.1.1 Calibration procedure

1. If present, disconnect the patient circuit from the inspiratory port (open to atmosphere).
2. Access the Calibration menu.
   - In the standby mode, push the **System Setup** key.
   - On the System Setup menu, select ***Install/Service*** (23-17-21).
   - On the Install/Service menu, select ***Calibration***.
3. On the Calibration menu, select ***O2 FCV***.
   - On the O2 FCV menu, select ***Start Calibration*** and allow the system to perform the calibration procedure.
   - When O2 FCV calibration is complete (passed), select ***Previous Menu***.
4. On the Calibration menu, select ***Air FCV***.
   - On the Air FCV menu, select ***Start Calibration*** and allow the system to perform the calibration procedure.
   - When Air FCV calibration is complete (passed), select ***Previous Menu***.
5. On the Calibration menu, select ***Exhalation Valve***.
   - Connect a patient circuit and block the patient port.
   - On the Exhalation Valve menu, select ***Start Calibration*** and allow the system to perform the calibration procedure.
   - When Exhalation Valve calibration is complete (passed), select ***Previous Menu***.

Backlight Test

6. On the Calibration menu, select ***Backlight Test***.
7. Select ***Start Test***.
8. The display will show the test running on light 1 and then on light 2. If the display goes completely blank or flickers during the test, one of the lights has failed.
9. Turn power off to exit the Install/Service menu.

5.2 Service level tests and calibration

The service level tests require the Windows based service application as described in Section 8.5, "*EV Service Application (PC based)*" .

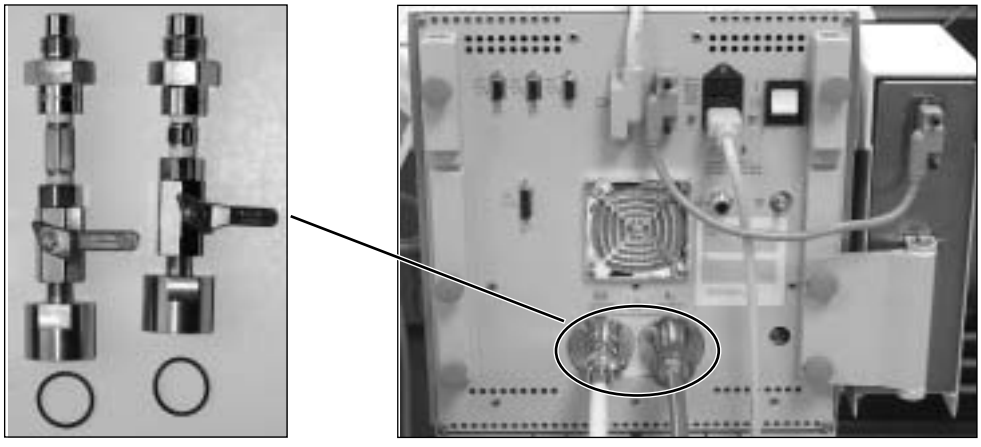
Note After completing the Service level test and calibrations, perform the Valve calibrations in Section 5.1.1.

5.2.1 Service application setup

1. Connect a Windows based PC to the serial port (RS-422 Port 3) of the EV using a USB to RS-422 converter (Refer to section 10.1.1).
2. Start the Service Application on the PC.
   - Open the ***VCB*** and ***VMB*** windows.
3. To establish communication between the PC Service Application and the EV, start up the system and enter the Service mode.

5.2.2 Test setup

1. Connect a manual shut-off valve to each gas supply inlet.
   - Remove inlet fittings from EV (ensure o-ring remains on adapter).
   - Connect shut-off valve to respective EV pipeline adapter.
   - Connect removed inlet fitting to respective shut-off valve.
2. Close both shut-off valves.
3. Connect pipeline supplies to each shut-off valve.



5.2.3 Vent engine debris clean-out

This procedure is needed only if:

- The pneumatic system within the vent engine was serviced; that is, components were replace or removed for evaluation.
- A gas inlet filter was replaced.

Clean-out procedure

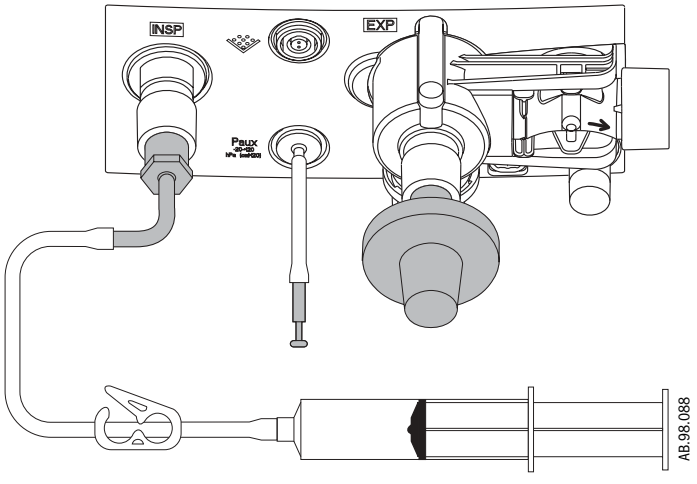
1. Open both shut-off valves.
2. Verify that the inspiratory outlet is open to atmosphere (not plugged).
3. On the VCB screen:
   - Verify that the ***Air*** and ***O2 Flow Valve***s are energized (☑).
   - Set the ***Air DAC*** counts to 60,000 (fully open).
   - Set the ***O2 DAC*** counts to 60,000 (fully open).
4. After 20 seconds:
   - Close both shut-off valves.
   - Set the ***Air DAC*** counts to zero (closed).
   - Set the ***O2 DAC*** counts to zero (closed).

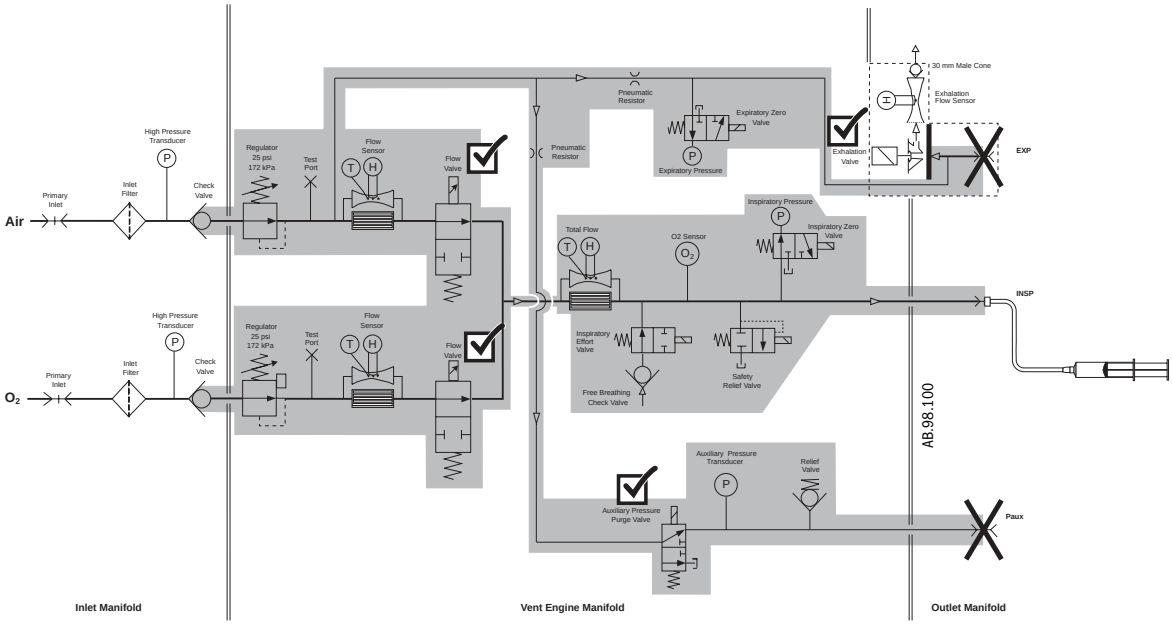
Note Closing the shut-off valves before setting the flow DAC counts to zero, bleeds pressure from the system.

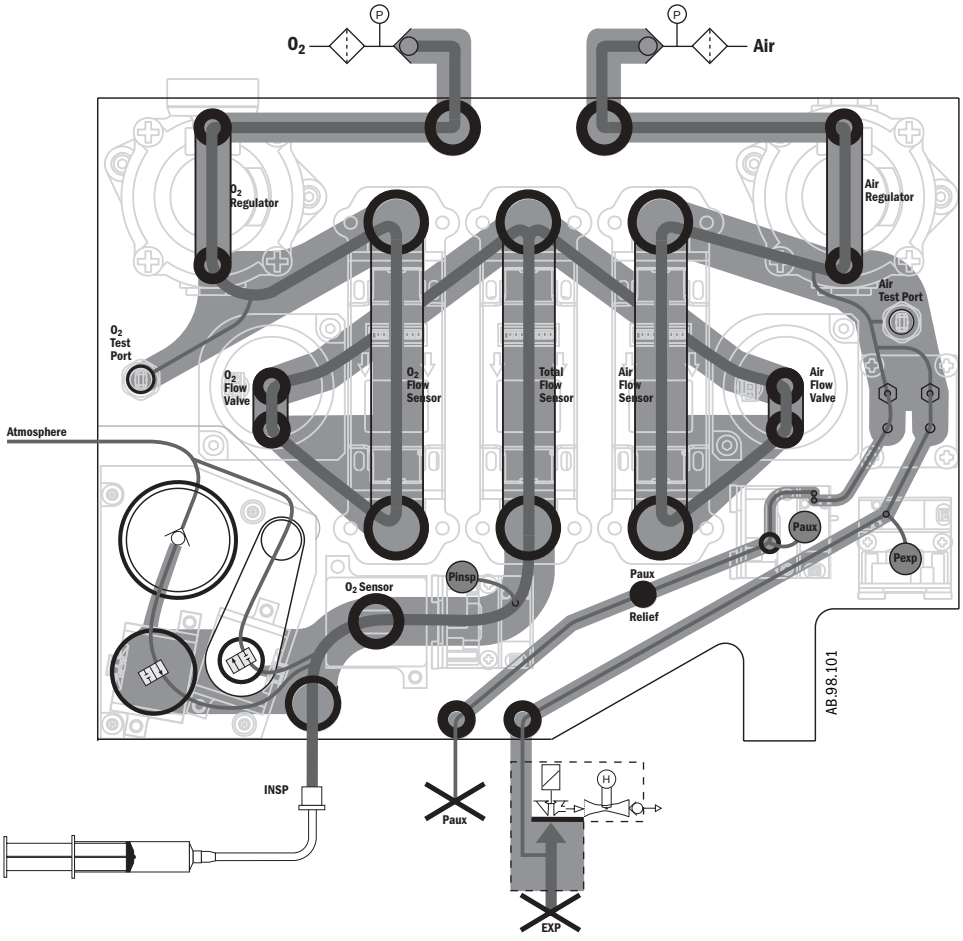
5.2.4 Vent engine leak test (low pressure)

1. Verify that both shut-off valves are closed.
2. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Verify that the ***Air Flow Valve***, ***O2 Flow Valve*** and the ***Exhal***ation ***Flow Valve*** are energized (☑).
   - Set the ***Air DAC***, ***O2 DAC***, and the ***Exh***alation ***DAC*** counts to 60,000 (this will release all pressurized gas from the system).
3. Attach the "low-pressure test tool" to the ***INSP***iratory outlet.
4. Plug the following ports:
   - Expiratory inlet.
   - Auxiliary pressure port.
5. Using the low pressure test tool, increase the pressure in the low pressure side of the system until the measured ***Expiratory Press***ure (VMB), ***Auxiliary Press***ure (VCB), and ***Inspiratory Press***ure (VCB) readings indicate 70 cmH2O.

   Note: Ensure that the three pressures are stable and approximately equal (within 5 cmH2O).
6. Once 70 cmH2O is reached, clamp the tube on the low pressure test tool to prevent gas flow from the ***INSP***iratory outlet.
7. On the VCB screen, select ***Low P Leak*** to start the low pressure leak test.
8. After the test is complete (15 seconds):
   - Verify that the displayed ***Leak*** rate does not exceed 10 ml/min.
   - If the leak rate exceeds 10 ml/min, refer to Section 7.2 to help identify the cause of the leak.
9. Remove the test tool from the ***INSP***iratory outlet.
10. Remove the plugs from the ***EXP***iratory inlet and the ***Paux*** port.
11. De-energize (☐) the ***Aux***iliary ***Press***ure ***Purge*** valve.

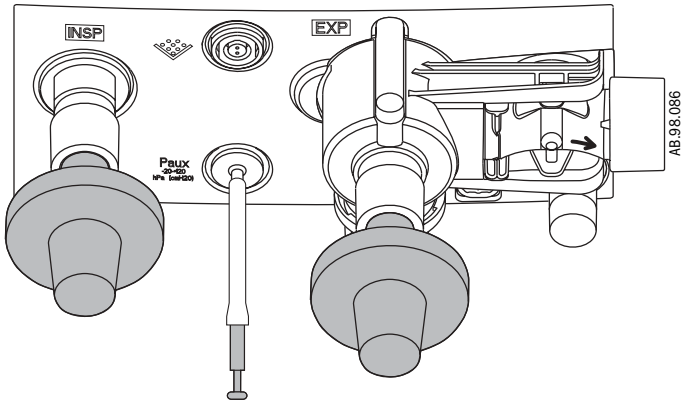


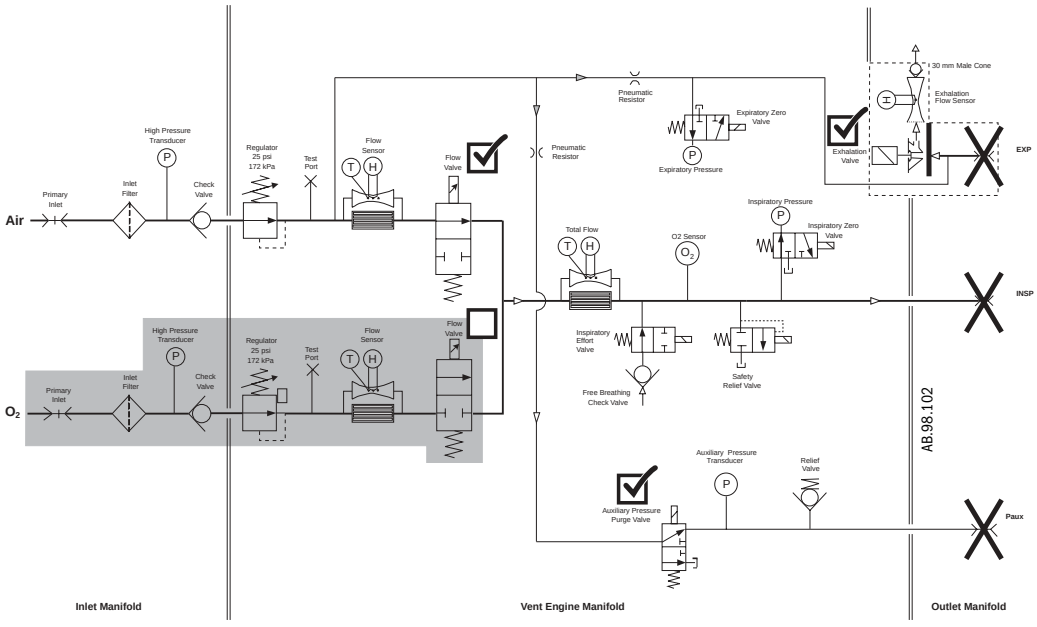

Air
O2
Primary Inlet
Inlet Filter
High Pressure Transducer
Check Valve
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.100
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold

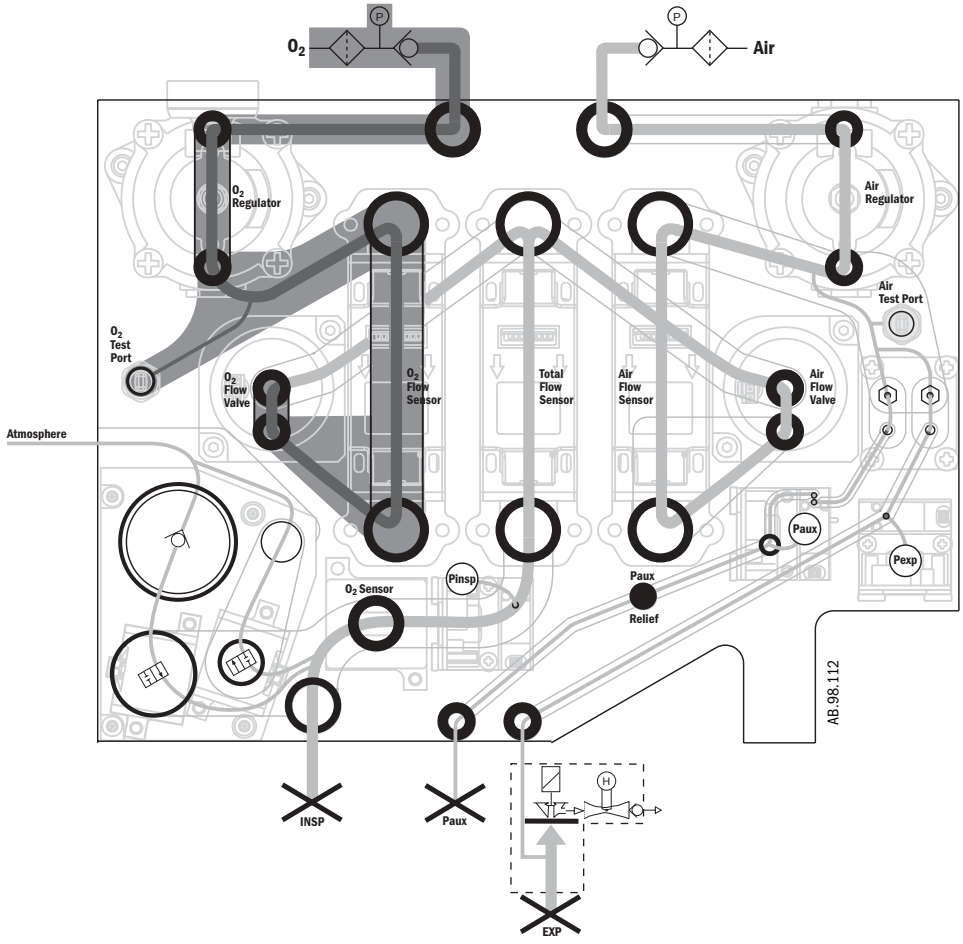

O2
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.101
INSP
Paux
EXP

5.2.5 Vent engine leak test (high O_2 pressure)

1. Open the manual O_2 shut-off valve.
2. On the VMB screen:
   - Verify that the measured ***O2 Supp***ly ***Press***ure = pipeline pressure.
   - Verify that the measured ***Air Supp***ly ***Press***ure = 0.0 psig.
3. Verify that the inspiratory outlet is open to atmosphere (not plugged).
4. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Verify that the ***Exhal***ation ***Flow Valve*** is energized (☑).
   - Set the ***Exh***alation ***DAC*** counts to 60,000.
   - Verify that the ***Air Flow Valve*** is energized (☑).
   - Set the ***Air DAC*** counts to 60,000 (this will release any air pressure in the system).
   - De-energize (☐) the ***O2 Flow Valve***.
5. Plug the following ports:
   - ***INSP***iratory outlet.
   - ***EXP***iratory inlet.
   - Auxiliary pressure port (***Paux***).
6. Close the manual O_2 shut-off valve.
7. On the VCB screen, select ***High O2 Leak*** to start the test.
8. After the test is complete (15 seconds):
   - Verify that the displayed ***Leak*** rate does not exceed 26 ml/min.
   - if not, troubleshoot for leaks in the shaded area.
9. Remove the plugs from the ***INSP***iratory, ***EXP***iratory, and ***Paux*** ports.
10. De-energize (☐) the ***Aux***iliary ***Press***ure ***Purge*** valve.

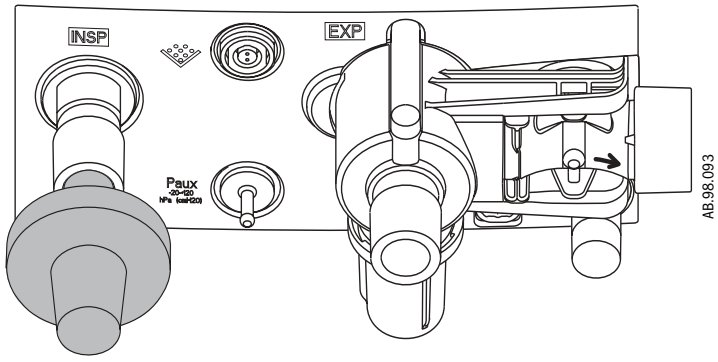


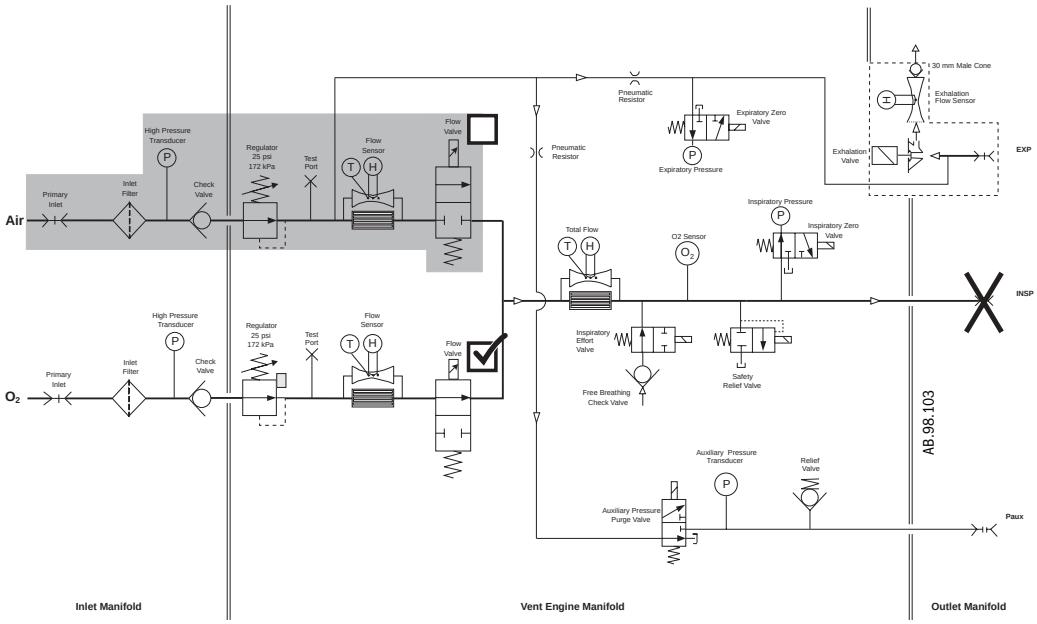

Air
O2
Primary Inlet
Inlet Filter
High Pressure Transducer
Check Valve
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
AB.98.102
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


O2
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.112
INSP
Paux
EXP

5.2.6 Vent engine leak test (high Air pressure)

1. Open the manual Air shut-off valve.
2. On the VMB screen:
   - Verify that the measured ***Air Supp***ly ***Press***ure = pipeline pressure.
   - Verify that the measured ***O2 Supp***ly ***Press***ure = 0.0 psig.
3. Verify that the ***INSP***iratory outlet is open to atmosphere (not plugged).
4. On the VCB screen:
   - Energize (☑) the ***O2 Flow Valve***.
   - Set the ***O2 DAC*** counts to 60,000 (this will release any O_2 pressure in the system).
   - De-energize (☐) the ***Air Flow Valve***.
5. Plug the ***INSP***iratory outlet.
6. Close the manual Air shut-off valve.
7. On the VCB screen, select ***High Air Leak*** to start the test.
8. After the test is complete (15 seconds):
   - Verify that the displayed ***Leak*** rate does not exceed 50 ml/min.
   - if not, troubleshoot for leaks in the shaded area.
9. Remove the plug from the ***INSP***iratory outlet.




Air
O2
Primary Inlet
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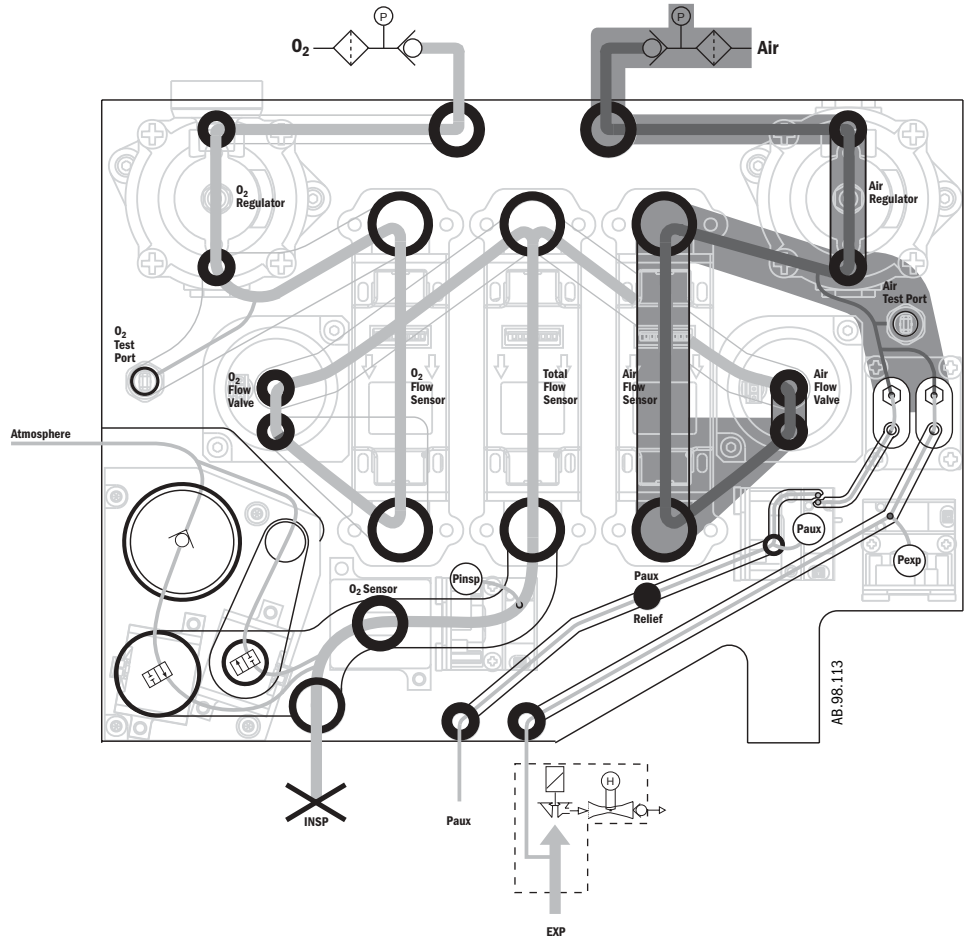
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.103
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


O2
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.113
INSP
Paux
EXP

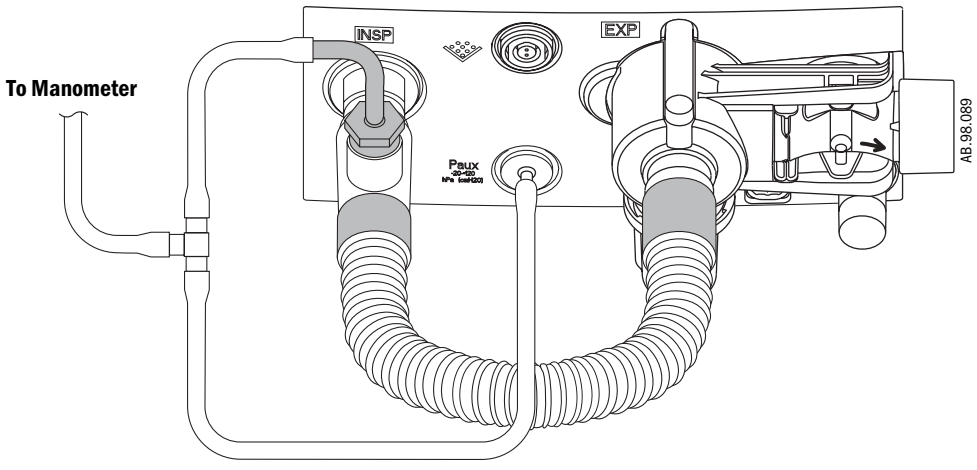
5.2.7 Calibrate airway pressure transducer Zero and Span

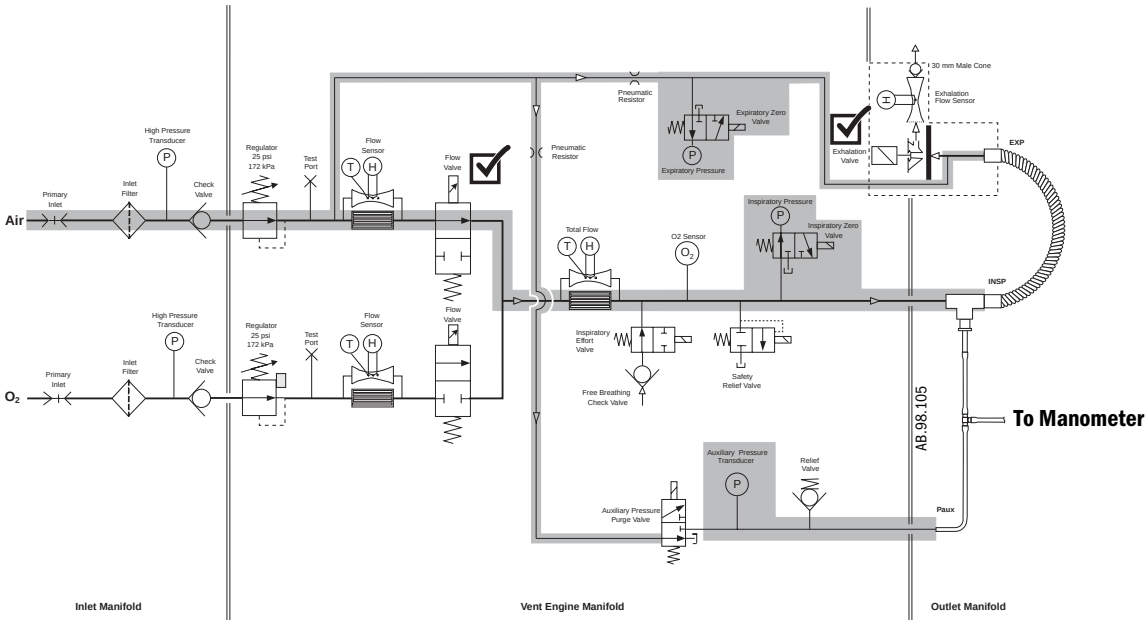
This procedure calibrates the Inspiratory, Expiratory, and Auxiliary pressure transducers.

Note: If Air is not available, the O_2 supply can be used to calibrate the pressure transducers. The Service Application senses which supply is available and, in step 5, activates the corresponding flow valve.

1. Start up the system and enter the Install/Service mode.
2. Verify that the ventilator passes the low pressure leak test (Section 5.2.4).
3. Attach the test setup to the EV as shown in the illustration below.
   - Connect a tee adapter to the ***INSP***iratory outlet.
   - Connect a short patient circuit tube from the tee adapter to the ***EXP***iratory inlet.
   - Connect a pressure sensing tube from the Inspiratory tee to a manometer and to the Auxiliary pressure port (***Paux***).
4. Open the manual Air (O_2) shut-off valve.
5. On the VCB screen:
   - Verify that the ***Exhal***ation ***Flow Valve*** is energized (☑).
   - Verify that the ***Air Flow Valve*** is energized (☑).
   - Select ***Start Paw Span*** (~2 L/min established through Air (O_2) flow valve).
   - Adjust the ***Span DAC Value*** (Exhalation valve) reading (start at approximately 40,000) until the manometer reading equals 100 ±0.2 cmH_2O.
6. At 100 cmH_2O, select ***End Paw Span***.
7. Close the manual Air (O_2) shut-off valve.
8. Remove the test setup.

Note If the span calibration is aborted or failed, the last known good calibration will be used.

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Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
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Auxiliary Pressure Transducer
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Auxiliary Pressure Purge Valve
Paux
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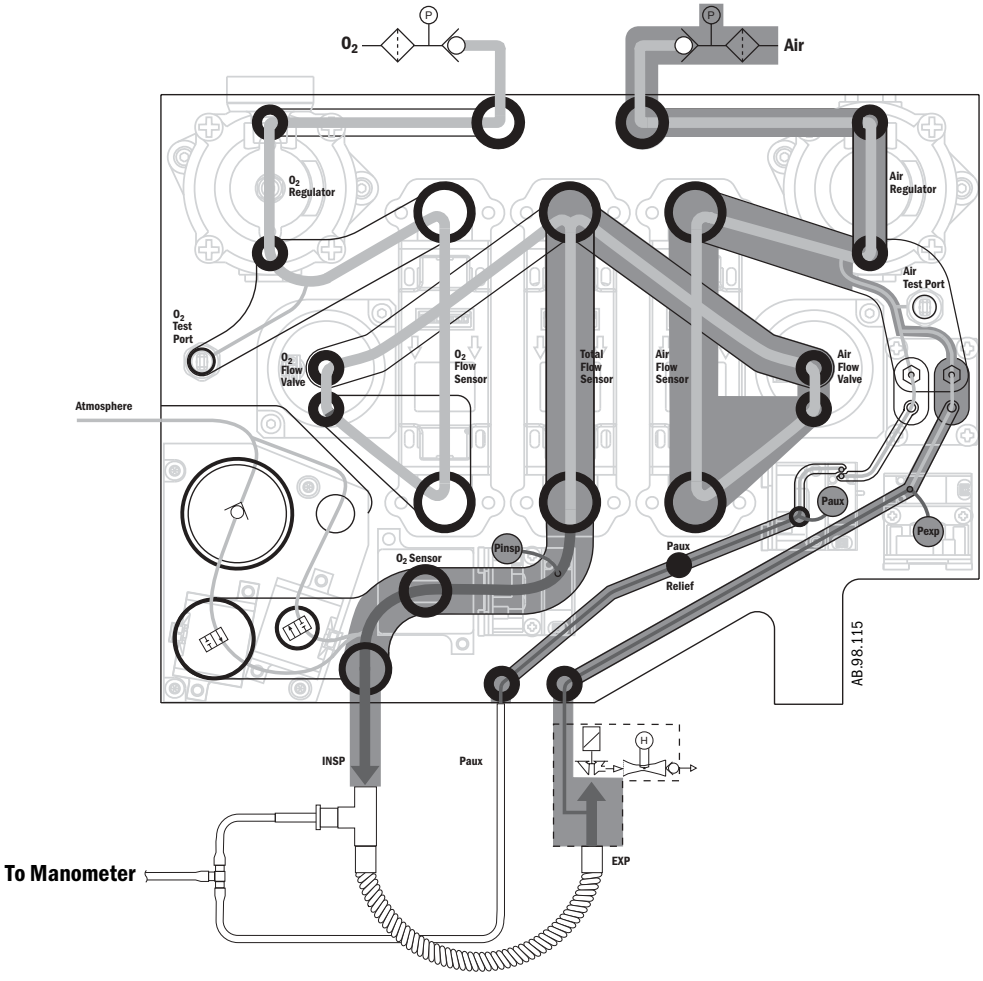
Vent Engine Manifold
Outlet Manifold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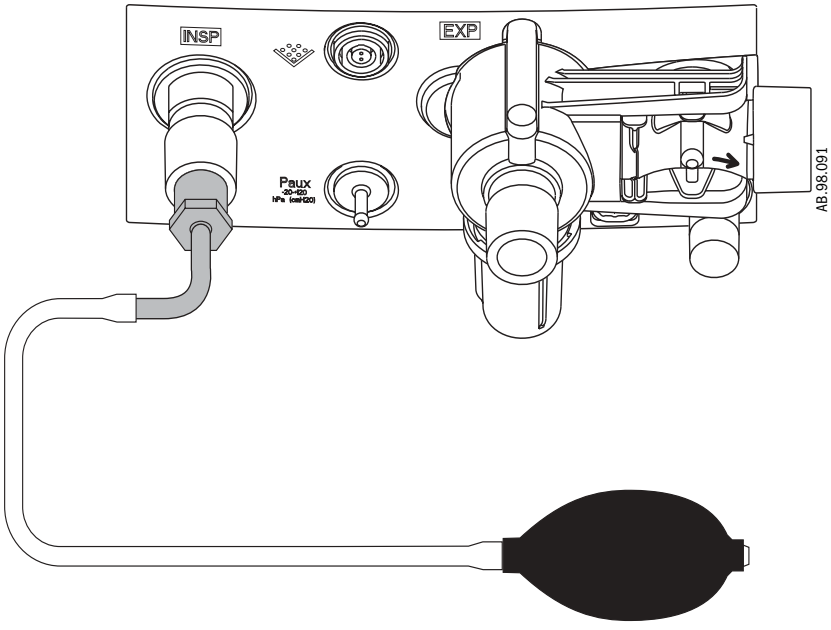
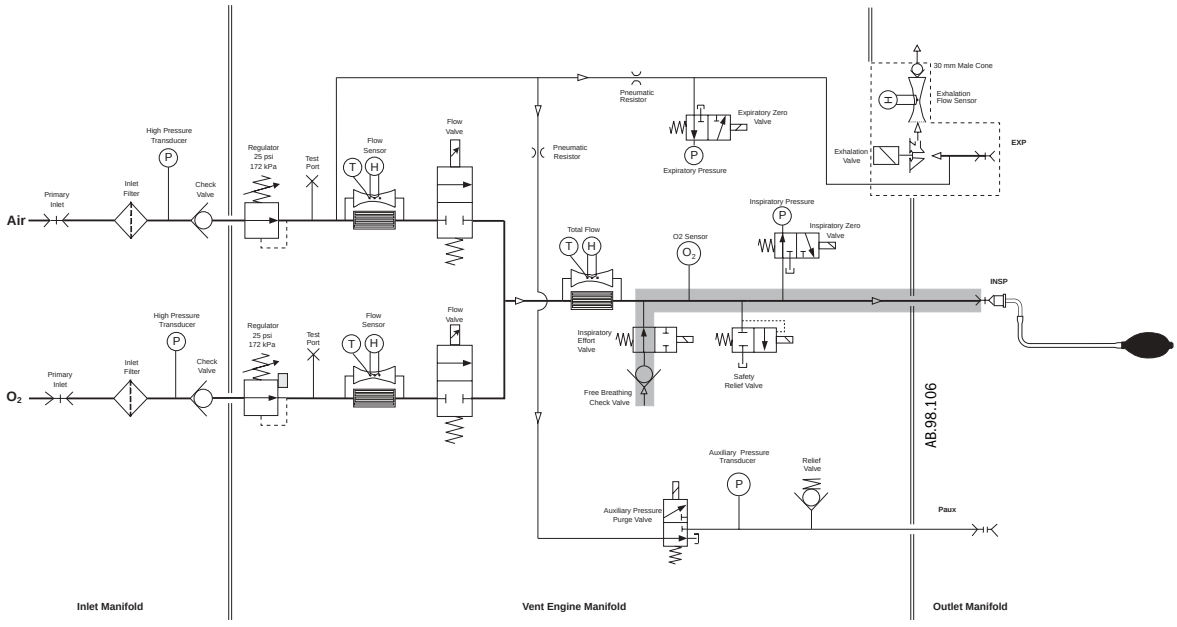
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.115
INSP
Paux
EXP
To Manometer

5.2.8 Verify operation of free- breathing valve

1. Ensure both manual shut-off valves are closed.
2. Connect a negative pressure squeeze bulb to the ***INSP***iratory outlet.
3. Fully depress the bulb a minimum of 10 times.
4. On the VCB screen:
   - Verify that the measured ***Inspiratory Press***ure is more positive than - 3 cmH_2O at all times.
   - if not, troubleshoot the free-breathing check valve and the inspiratory effort valve.
5. Disconnect the squeeze bulb from the ***INSP***iratory outlet.

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Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
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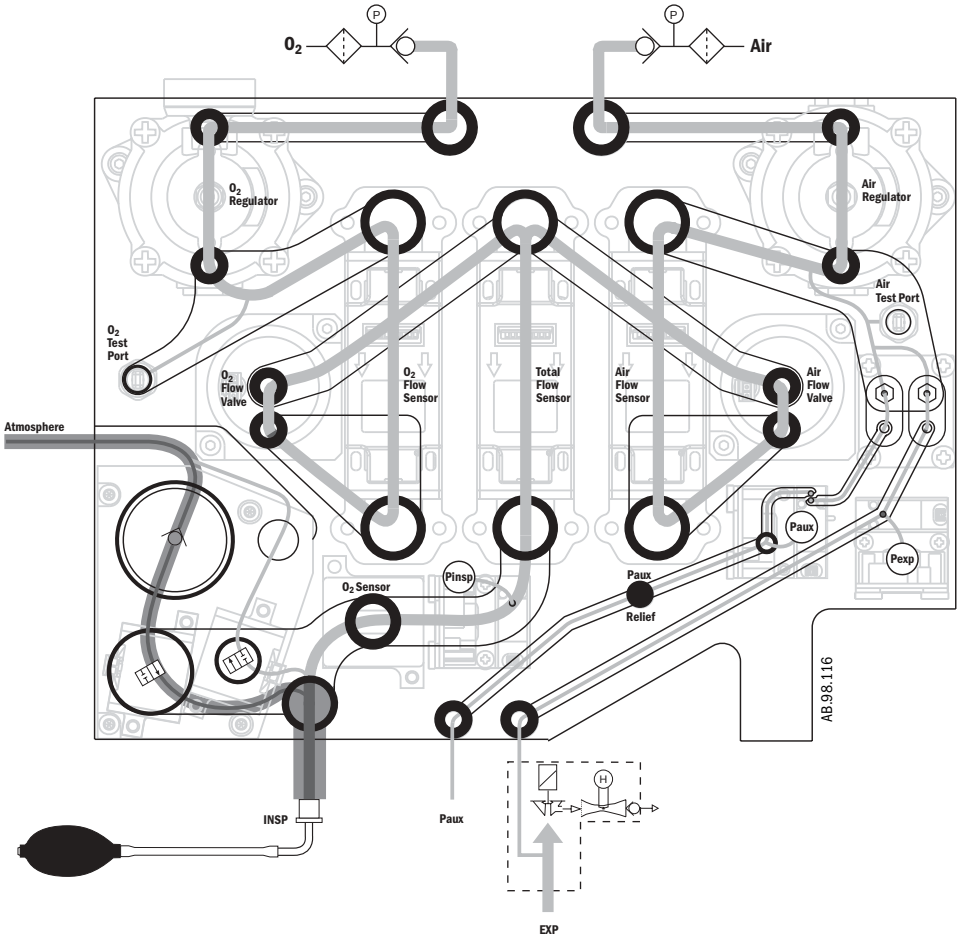
Vent Engine Manifold
Outlet Manifold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Air Regulator
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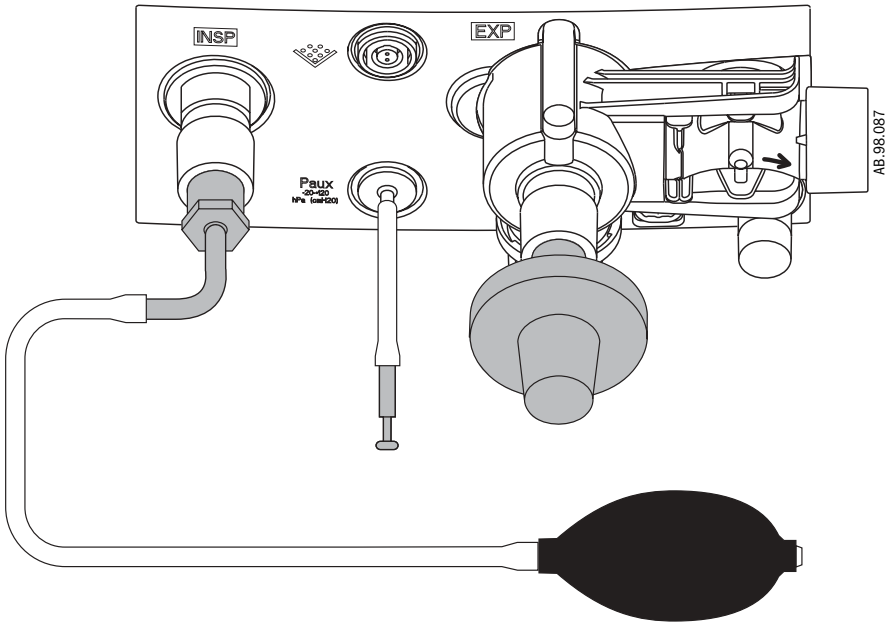
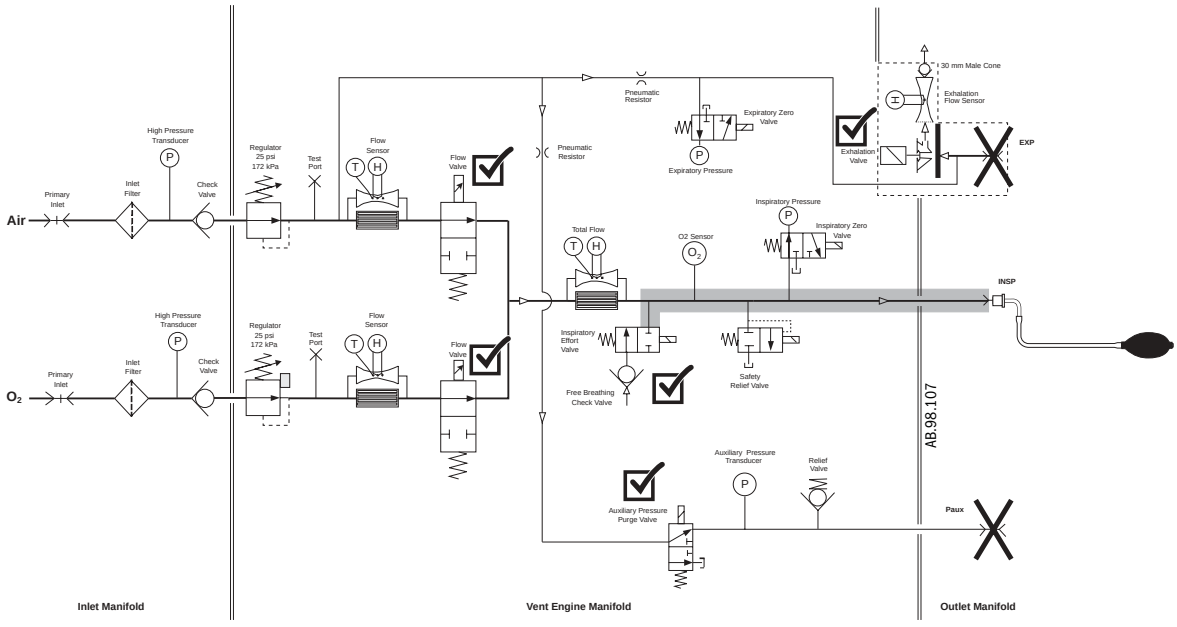
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.116
INSP
Paux
EXP

5.2.9 Verify operation of inspiratory effort valve

1. Ensure both manual shut-off valves are closed.
2. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
   - Energize (close) the inspiratory effort valve (☑ ***Effort Valve Energized***).
   - Verify that the ***Air Flow Valve***, ***O2 Flow Valve*** and the ***Exhal***ation ***Flow Valve*** are energized (☑).
   - Set the ***Air DAC***, ***O2 DAC***, and the ***Exh***alation ***DAC*** counts to 60,000.
3. Connect a negative pressure squeeze bulb to the ***INSP***iratory outlet.
4. Plug the ***EXP***iratory inlet and the Auxiliary pressure port (***Paux***).
5. Fully depress the squeeze bulb.
   - The bulb should not fully inflate in less than 30 seconds.
   - if not, troubleshoot the inspiratory effort valve.
6. Disconnect the squeeze bulb from the ***INSP***iratory outlet.
7. De-energize (open) the inspiratory effort valve (☐ ***Effort Valve Energized***).
8. Set the ***Air DAC***, ***O2 DAC***, and ***Exh***alation ***DAC*** counts to zero.

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Test Port
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Expiratory Zero Valve
Expiratory Pressure
Exhalation Valve
30 mm Male Cone
Exhalation Flow Sensor
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
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Auxiliary Pressure Purge Valve
Paux
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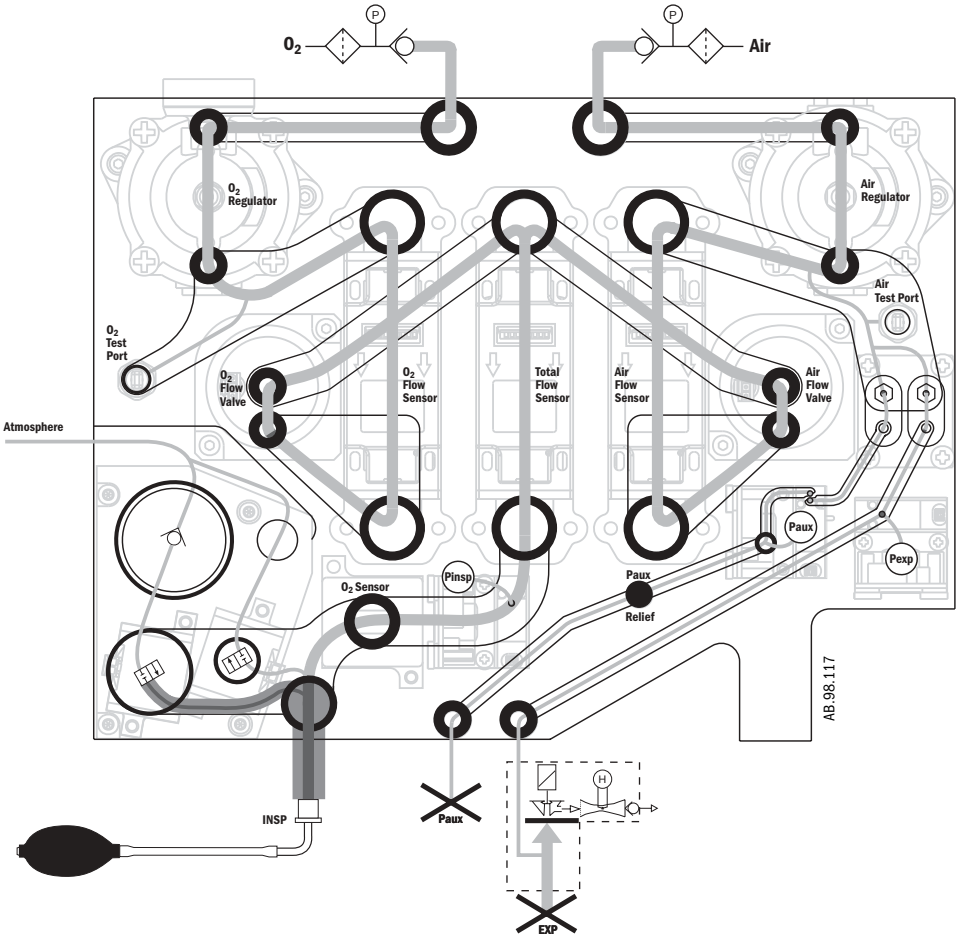
Vent Engine Manifold
Outlet Manifold


O2
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O2 Regulator
Air Regulator
Air Test Port
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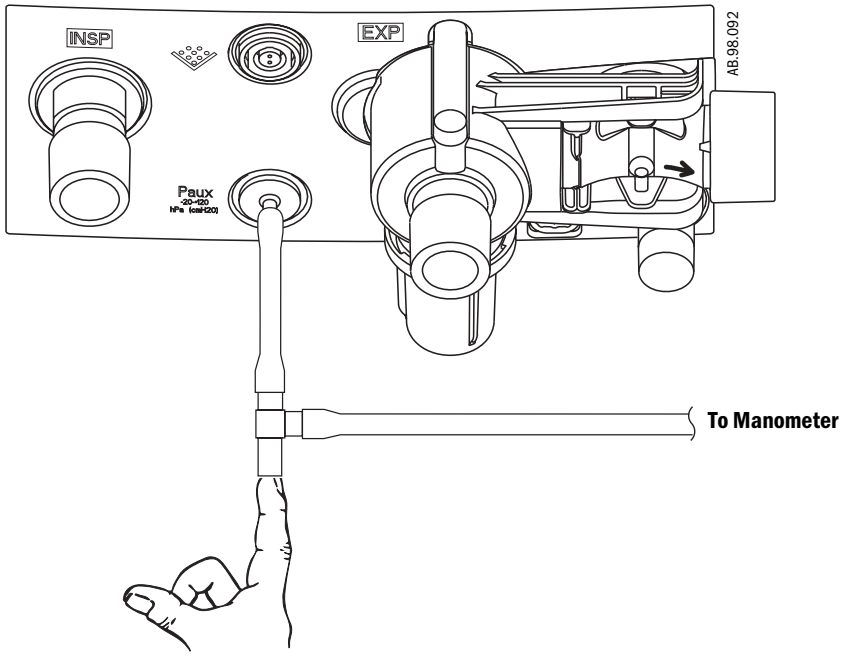
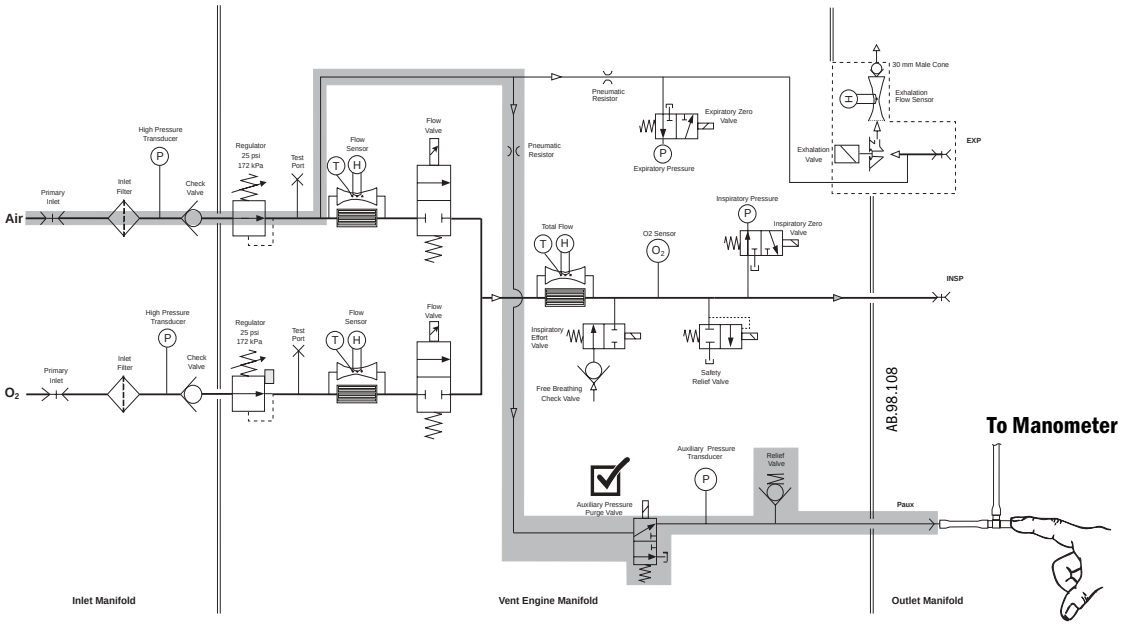
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.117
INSP
Paux
EXP

5.2.10 Verify operation of auxiliary pressure relief valve

1. Connect a manometer to the auxiliary pressure port (***Paux***) using a tee fitting and a short piece of 3-mm (1/8 inch) tubing.
2. Open the manual Air shut-off valve.
3. On the VCB screen:
   - Energize (☑) the ***Aux***iliary ***Press***ure ***Purge*** valve.
4. Block the outlet of the tee.
5. Verify that the pressure indicated by the manometer (not the PC based application) is greater than 90 cmH_2O but less than 230 cmH_2O.

   Caution: Do not allow the pressure to build up over 250 cmH_2O.
   - if not, troubleshoot the relief valve.
6. Close the manual Air shut-off valve.
7. Remove the test setup.

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High Pressure Transducer
Check Valve
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.108
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Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
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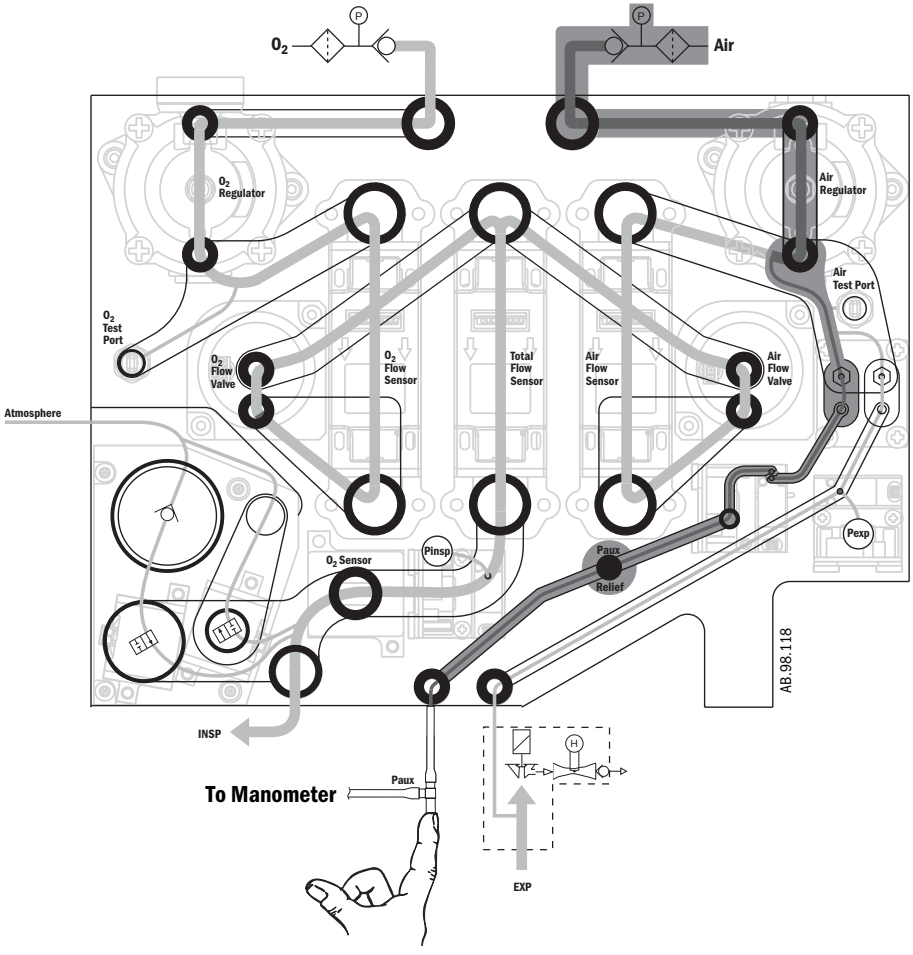
Vent Engine Manifold
Outlet Manifold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Air Regulator
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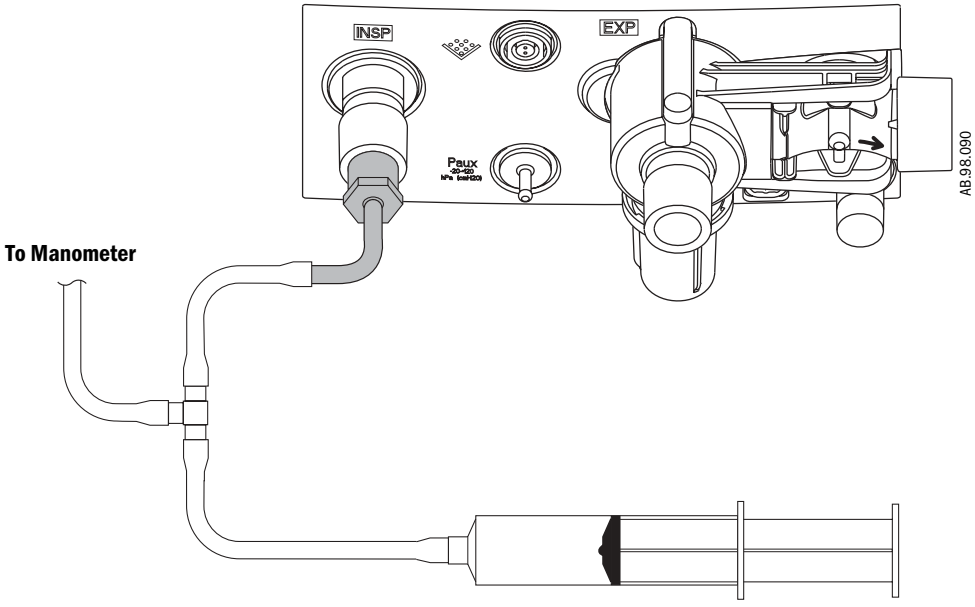
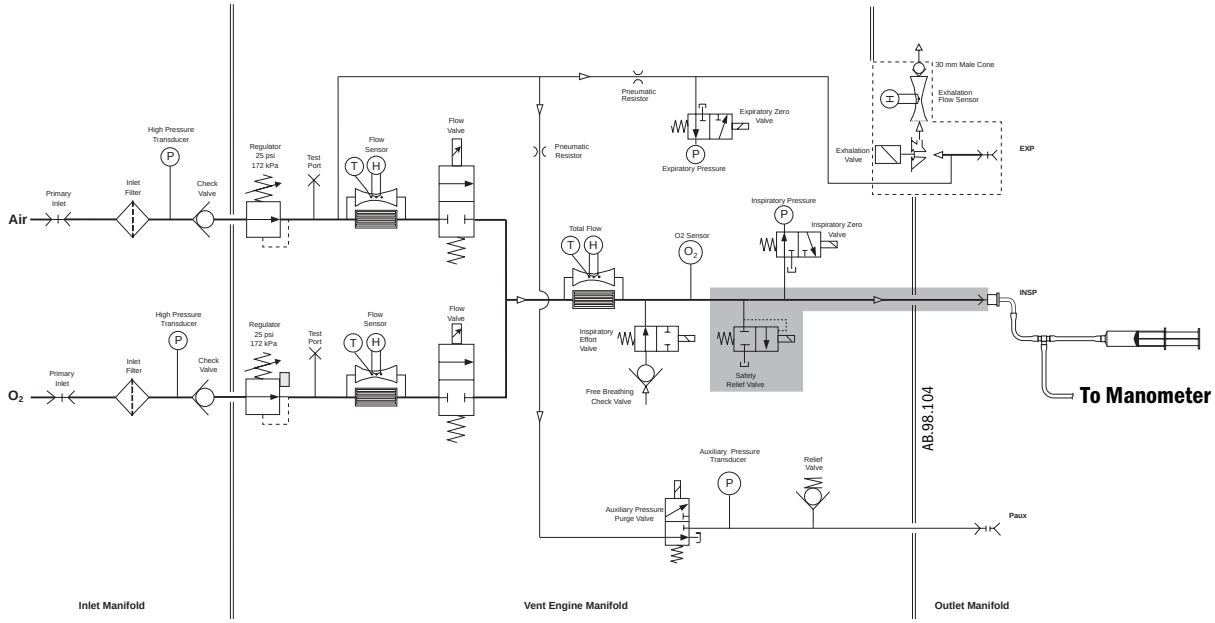
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.118
INSP
To Manometer
Paux
EXP

5.2.11 Mechanical over-pressure valve test

1. Verify that the ventilator passes the low pressure leak test (Section 5.2.4).
2. Turn the ventilator off.
3. Using a syringe, inject 60 ml of air into the ventilator through the ***INSP***iratory port.
4. After the entire volume is delivered, verify that the pressure reading on the manometer is less than 130 cmH2O.
   - if not, troubleshoot the safety relief valve.

Note: Pressure may spike higher than 130 cmH2O during 60 ml volume delivery if delivered at a rate greater than 4 l/min.

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Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
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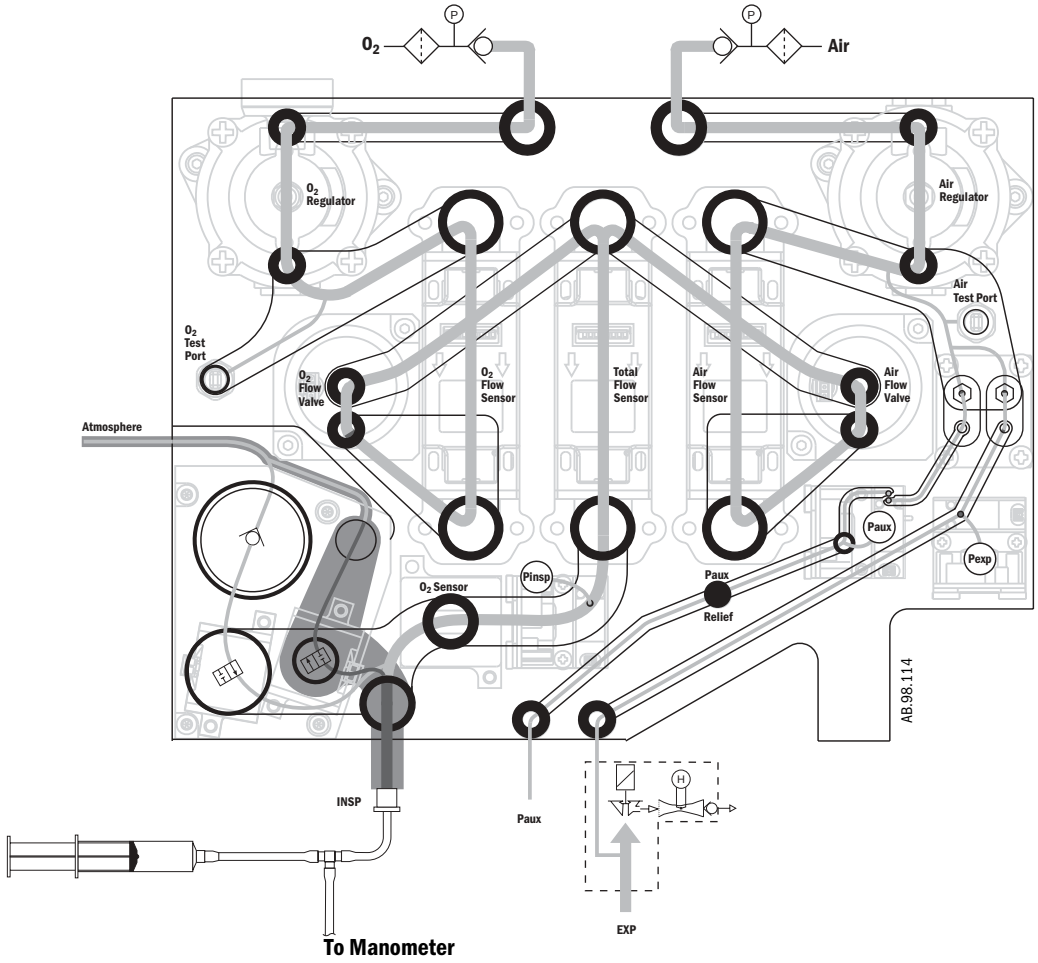
Outlet Manifold


O2
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Air Regulator
Air Test Port
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O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.114
INSP
Paux
EXP
To Manometer

5.2.12 Verify regulator output pressure

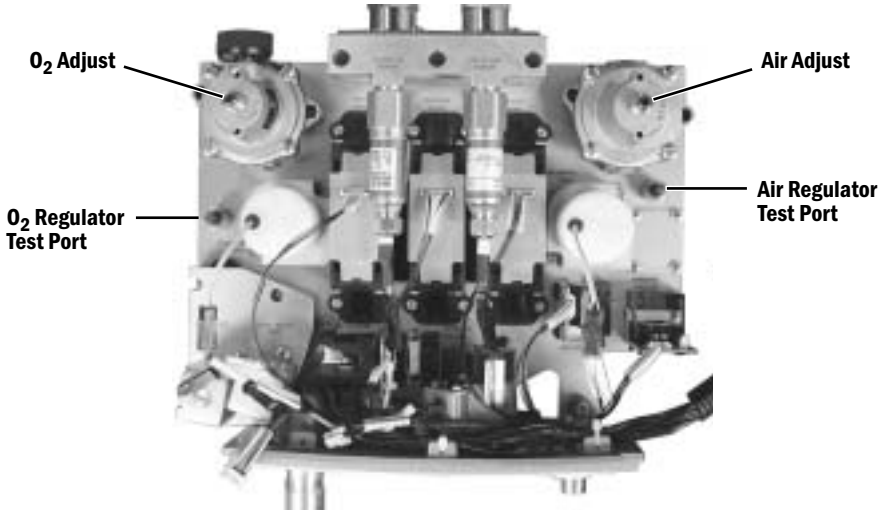
The regulator output pressure should be checked during battery replacement intervals or whenever the unit is already opened for other reasons.

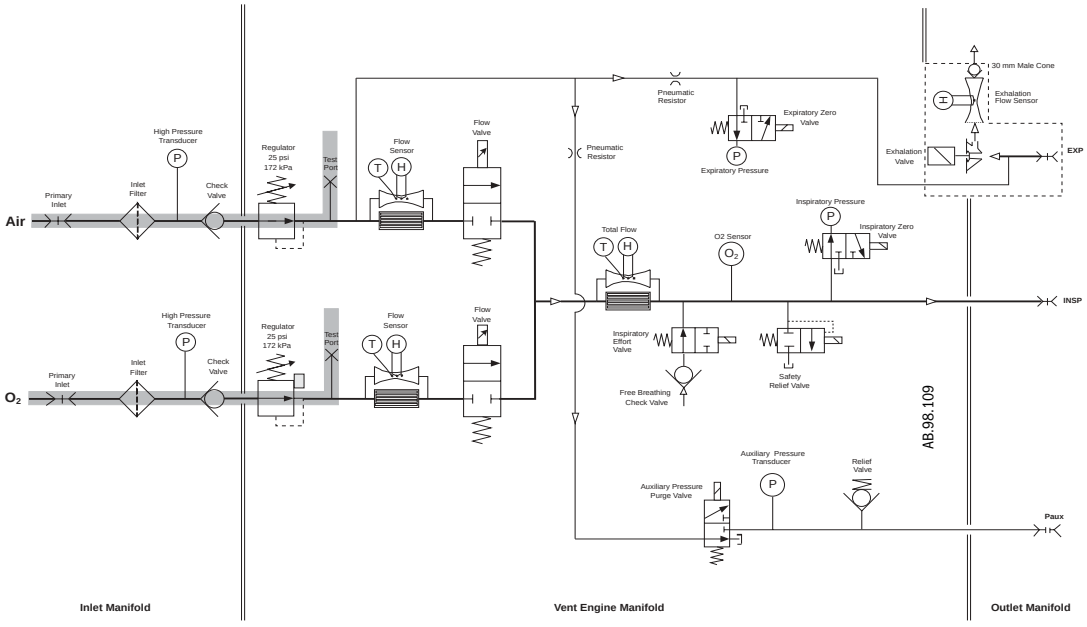
Air regulator

1. Remove the plug from the Air regulator outlet test port.
2. Connect a test pressure gauge to the Air regulator outlet test port.
3. Open the manual Air shut-off valve.
4. On the VCB screen:
   - Verify that the ***Air Flow Valve*** is energized (☑).
   - Adjust the ***Air DAC*** reading (start at approximately 9,500) until the Air flow reading is 15 l/min.
5. Verify that the test gauge indicates 172 ± 0.69 kPa (25 ± 0.10 psi).
6. If required, adjust the regulator.
   - Be sure to tighten the locking nut after adjustment.
7. Close the manual Air shut-off valve.
8. Remove the test gauge and plug the test port.

O_2 regulator

1. Remove the plug from the O_2 regulator outlet test port.
2. Connect a test pressure gauge to the O_2 regulator outlet test port.
3. Open the manual O_2 shut-off valve.
4. On the VCB screen:
   - Verify that the ***O_2 Flow Valve*** is energized (☑).
   - Adjust the ***O_2 DAC*** reading (start at approximately 9,500) until the Air flow reading is 15 l/min.
5. Verify that the test gauge indicates 172 ± 0.69 kPa (25 ± 0.10 psi).
6. If required, adjust the regulator.
   - Be sure to tighten the locking nut after adjustment.
7. Close the manual O_2 shut-off valve.
8. Remove the test gauge and plug the test port.

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Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Safety Relief Valve
Free Breathing Check Valve
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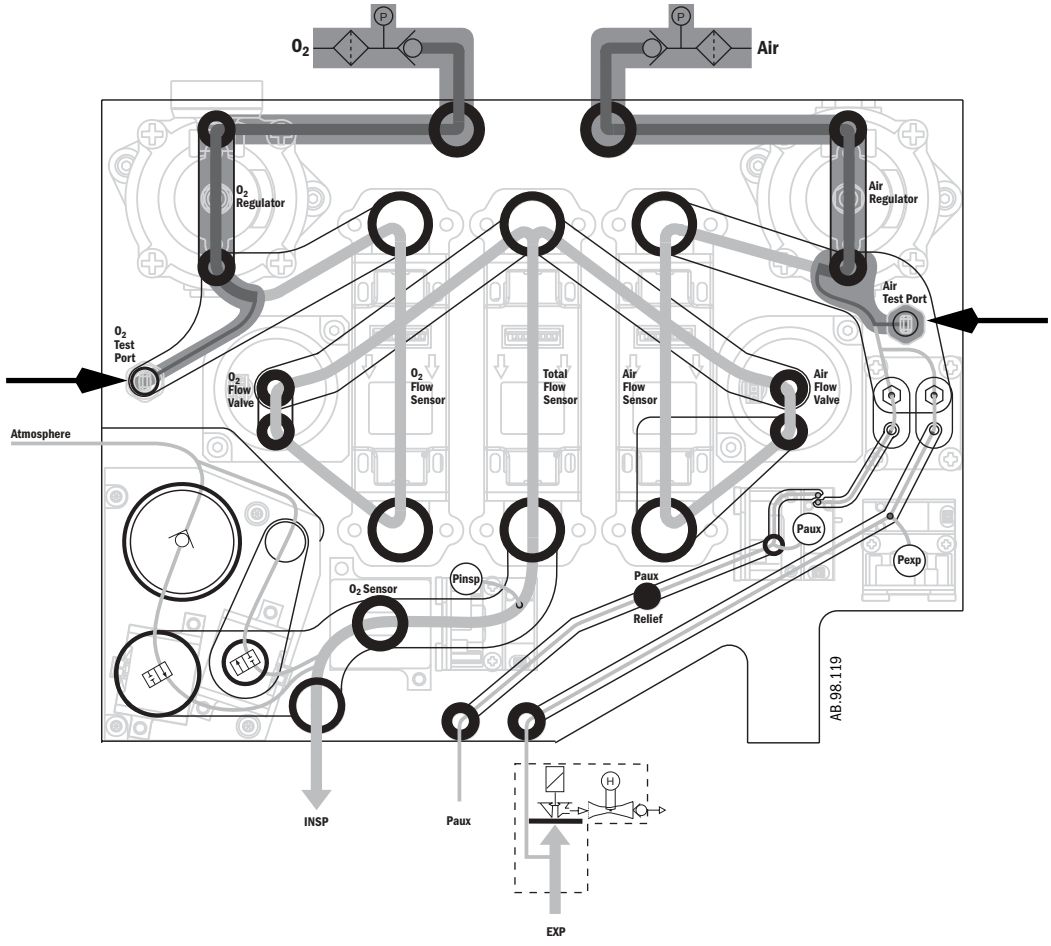
Outlet Manifold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Air Regulator
Air Test Port
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O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.119
INSP
Paux
EXP

Notes

6 Maintenance

In this section

This section covers the regular maintenance procedures (minimum requirements) needed to make sure that the Engström Ventilator operates to specifications.

6.1 Engström Ventilator planned maintenance 6-2

6.1.1 Every twelve (12) months 6-2

6.1.2 Every forty-eight (48) months 6-2

6.2 Battery capacity test 6-3

⚠ WARNINGS

Do not perform testing or maintenance on the Engström Ventilator while it is being used on a patient. Possible injury can result.

Items can be contaminated due to infectious patients. Wear sterile rubber gloves. Contamination can spread to you and others.

Obey infection control and safety procedures. Used equipment may contain blood and body fluids.

6.1 Engström Ventilator planned maintenance

Serial Number:	Date: (YY/MM/DD) / /
Hospital:	Performed by:
☐ 12 months ☐ 24 month ☐ 48 month	☐ _____

6.1.1 Every twelve (12) months

Perform the following steps every 12 months.
For details, refer to the sections listed.

- ☐ 1. If required, adjust the Display Unit arm joints (*Section 9.5*).
- ☐ 2. If required, adjust patient monitoring module rack arm.
- ☐ 3. Visually inspect Vent Engine fan filter. Clean or replace as needed.
- ☐ 4. Visually inspect Display Unit fan filter. Clean or replace as needed.
- ☐ 5. Visually inspect exhalation valve assembly. Clean or replace as needed.
- ☐ 6. Visually inspect gas inlet filters (O_2 and Air). Replace as needed.
- ☐ 7. Complete the battery capacity test (*Section 6.2*).
- ☐ 8. Electrical safety tests (*Section 3.5*).
- ☐ 9. Complete all Service level tests and calibrations (*Section 5.2*).
- ☐ 10. Complete all Super-User level tests and calibrations (*Section 5.1*).
- ☐ 11. Complete the Checkout procedure (*Section 3*).

6.1.2 Every forty-eight (48) months

In addition to the 12-month requirements, replace the following parts every 48 months. All parts should be replaced before performing the checks, tests, and calibrations.

- ☐ 1. Replace the system batteries* (Stock Number 1009-5682-000).

*__Note__: Refer to the "*Battery capacity test*" in *Section 6.2*.

6.2 Battery capacity test

Although replacement of the backup batteries is recommended at the end of 4 years, batteries that pass the capacity test can be considered viable for battery backup of the system for up to 6 years at the discretion of the hospital.

Before testing the batteries, ensure that they are fully charged.

Test procedure

1. Turn the system on and start a case (simulated).
2. Disconnect the power cord from the mains outlet.
3. Allow the system to run on battery until it does an orderly shutdown.
4. Reconnect the power cord to a mains outlet.
5. Boot the system with the PCMCIA Service Application and access the Power Diagnostics function as detailed in Section 8.
   - On the Main Menu of the Service Application, select ***Power Diagnostics***.
   - On the Power Diagnostic menu, select ***Power Control***.
6. Page 1 of the Power Controller Power Diagnostics screen shows the 'Date battery Tested' (the last full battery discharge) and the 'Discharge Time'.
   - If the 'Discharge Time' is greater than 60 minutes, the batteries can be left in service for one more year.
   - If the 'Discharge Time' is less than 60 minutes, both batteries should be replaced.

Notes

7 Troubleshooting

In this section

7.1 Troubleshooting Checkout Failures 7-2
7.1.1 Paw Transducer Check 7-2
7.1.2 Barometric pressure test 7-2
7.1.3 Low Pressure Leak and Compliance Check 7-3
7.1.4 Safety Valve Relief and Back Pressure 7-3
7.1.5 Exhalation Valve Calibration Check 7-4
7.1.6 Exhalation Flow Sensor Calibration Test 7-4
7.1.7 Measure Breathing Circuit Resistance 7-4
7.1.8 Air Inspiratory Flow Sensor Calibration Check 7-5
7.1.9 O_2 Inspiratory Flow Sensor Calibration Check 7-5
7.1.10 O_2 Sensor Test and Calibration 7-5
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7.3 Alarm message troubleshooting chart 7-10
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7.1 Troubleshooting Checkout Failures

If the Automated Checkout (Section 3.2) results in failures, refer to the following sections to troubleshoot a specific failure.

7.1.1 Paw Transducer Check

The Paw Transducer Check can indicate a failure from four conditions:

1. Inspiratory Pressure Sensor Zero Failure:

   Test results indicate **Fail** and the ***Pinsp sensor out of range*** message is displayed.

   - Ensure proper connections.
   - Replace the Inspiratory Pressure Sensor board.
   - Replace the Inspiratory Zero Valve
   - Replace the Vent Control board (VCB).

2. Expiratory Pressure Sensor Zero Failure:

   Test results indicate **Fail** and ***Pexp sensor out of range*** message is displayed.

   - Ensure proper connections.
   - Replace the Expiratory Pressure Sensor board.
   - Replace the Expiratory Zero Valve.
   - Replace the Vent Monitor board (VMB).

3. Cannot achieve 34 cmH_2O pressure:

   Test results indicate **Fail** but no alarm message is displayed.

   - Ensure supply gas is connected.
   - Continue with other tests. If a significant leak is indicated during the Low Pressure Leak test, repair the leak then repeat this check.
   - Check respective Flow Control Valve for proper operation.

4. **Paw insp** and **Paw exp** are not within 4 cmH_2O when pressurized to 34 cm H_2O.

   Test results indicate **Fail** but no alarm message is displayed.

   - Use the Service Application to calibrate sensors (Section 5.2.7).
   - Replace the affected Sensor board(s) or Zero valves, if calibration fails.

If this check fails, all ventilation modes will still be available.

7.1.2 Barometric pressure test

A failure indicates that the difference between calculated barometric pressure based on the input altitude, and the measured barometric pressure is greater than 20%.

- Verify correct altitude setting.
- If setting is correct, calibrate the barometric sensor (Section 8.7.4).
- Replace the Vent Monitor board (VMB) - recalibrate barometric sensor.

If this check fails, all ventilator modes will still be available and the calculations will use the input altitude as basis for absolute pressure.

7.1.3 Low Pressure Leak and Compliance Check

No failures will be indicated. If there are errors in the calculation (negative values, divide by zero, etc.) the results will be dashed. The results of this calculation will be displayed after the Safety Relief Valve test is completed.

1. The first calculation is compliance and is based on the amount of time it takes for a 3 l/min flow to create 34 cmH_2O of pressure at the Pexp sensor. If this pressure cannot be achieved, no compliance information will be available.
2. The second calculation is the low pressure leak rate. It is based on the amount of pressure decay from 25 cmH_2O pressure in approximately 3 seconds. If the leak rate is greater than 1 L/min (@ 25 cmH_2O), the leak and compliance values will be dashed. This value can be useful in diagnosing other failures during checkout.
3. Finally, a correction based on the leak rate is applied to the compliance calculation and the information can be displayed.

7.1.4 Safety Valve Relief and Back Pressure

The Safety Valve Relief test checks the ability of the Safety Relief Valve to relieve all patient pressure on demand. Failures include:

1. Cannot achieve 30 cmH_2O pressure.

   The test will indicate **Fail** but no alarm message is displayed.

   - Ensure supply gas is connected.
   - A leak is indicated; repair the leak then repeat this check.

2. Once pressure stabilizes, the Safety Relief Valve is opened. If Pexp does not go to less than 2 cmH_2O within 250 msec, the test will indicate **Fail** and ***Relief Valve Failure*** message will be displayed.

   Use the Service Application to simulate this test.

   a. If pressure remains significantly above 2 cmH_2O:
      - Check the connections to the safety relief valve.
      - Ensure seat/seal interface is clean.
      - Replace the Manifold Assembly.

   b. If pressure is only slightly above 2 cmH_2O:
      - Re-zero pressure sensors.
      - Ensure seat/seal interface is clean.
      - If Exhalation Valve Calibration Check also fails, replace the Pexp sensor.
      - Repeat check.

3. If a flow of 75 l/min creates more than 10 cmH_2O pressure at Pexp sensor with the safety relief valve open, the test will indicate **Fail** and ***Relief Valve Failure*** message will be displayed.

   Use Service Application to simulate this test.

   - Check the connections to the safety relief valve.
   - Replace the Manifold Assembly.

If this test fails, no mechanical ventilation is allowed.

7.1.5 Exhalation Valve Calibration Check

The Exhalation Valve Calibration check uses the same relief test as above except with the Exhalation valve instead of the Safety Relief valve.

1. Cannot achieve 34 cmH_2O pressure.

   The test will indicate **Fail** but no alarm message is displayed.

   - Ensure supply gas is connected.
   - A leak is indicated; repair the leak then repeat this check.

2. If both the Relief Valve and Exhalation Valve tests fail and the leak rate is less than 2000, the most likely problem is with the Pexp Sensor not returning to zero:

   - Use the Service Application to apply 34 cmH_2O of pressure until stable, then release the pressure using either the Exhalation Valve or the Safety Relief Valve. The Pexp value must return to less than 2 within 250 msec. If not, re-zero and repeat or replace the Pexp sensor.

3. If only this check is failing:

   a. Use the Service Application to verify at least 3 l/min is generated by the FCV. If not:
      - Recalibrate the FCV.
      - Replace the FCV.
   b. Remove the Expiratory flow sensor.
      - If the check passes, replace the Expiratory Flow Sensor.
   c. Remove the Exhalation Valve Assembly and ensure the Voice coil shaft is clean and dry and moves freely without binding.
   d. Replace the Exhalation Valve Assembly.
   e. Replace the Voice coil assembly.

If this check fails, all ventilator modes will still be available.

7.1.6 Exhalation Flow Sensor Calibration Test

The Exhalation Flow Sensor Calibration test compares the Exhalation Flow Sensor output to the Total Flow Sensor output.

1. If only this test fails, replace the Exhalation Flow Sensor.
2. If the Air and/or O2 Inspiratory Flow Sensor calibration checks also fail, use the Service Application to determine the accuracy of the Total Flow Sensor.

If this test fails, all ventilator functions will still be available. The message ***Flow Sensor Error*** will be displayed.

7.1.7 Measure Breathing Circuit Resistance

The breathing circuit resistance is calculated from the amount of resistance created when 60 l/min is flowing through the circuit. It is calculated and displayed on the bottom of the screen. It represents the resistance of 1/2 of the breathing circuit.

7.1.8 Air Inspiratory Flow Sensor Calibration Check

The Air Inspiratory Flow Sensor Calibration check verifies that the Air Flow Sensor is functioning and compares the flow and temperature measurements with the total flow sensor.

1. If both the Air and O_2 Flow Sensors fail this check, replace the Total Flow Sensor.
2. Otherwise, replace the Air Flow Sensor.

If this check fails, all ventilator functions will still be available. The message ***FlAir Control Error*** will be displayed.

7.1.9 O_2 Inspiratory Flow Sensor Calibration Check

This check verifies that the O_2 Flow Sensor is functioning and compares the flow and temperature measurements with the total flow sensor.

1. If both the Air and O_2 Flow Sensors fail this check, replace the Total Flow Sensor.
2. Otherwise, replace the O_2 Flow Sensor.

If this check fails, all ventilator functions will still be available. The message ***FlO2 Control Error*** will be displayed.

7.1.10 O_2 Sensor Test and Calibration

This test/calibration will only be performed if both Air and O_2 are connected. The O_2 offset is calibrated while flowing 30 l/min of Air and the O_2 gain is calibrated with 30 l/min of O_2.

Calibration is verified by flowing 15 l/min Air and 15 l/min O_2 and comparing the sensor output to the calculated valve (approximately 60.5%).

If this check fails, all ventilator functions will still be available.

7.2 Troubleshooting Vent Engine Leaks

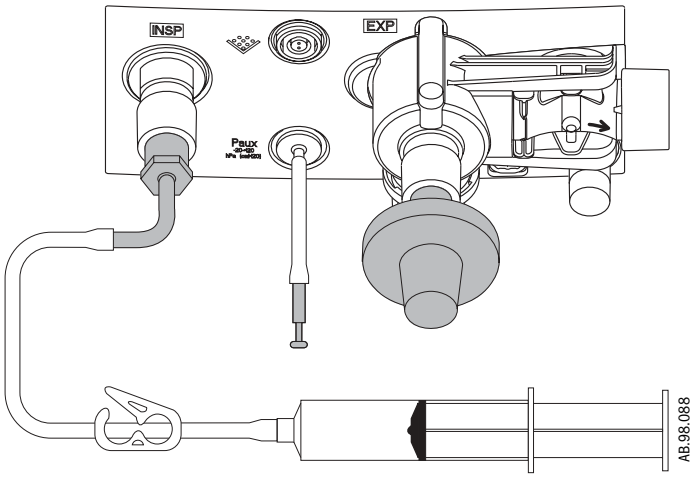
If the vent engine leak test (Section 5.2.4) fails,

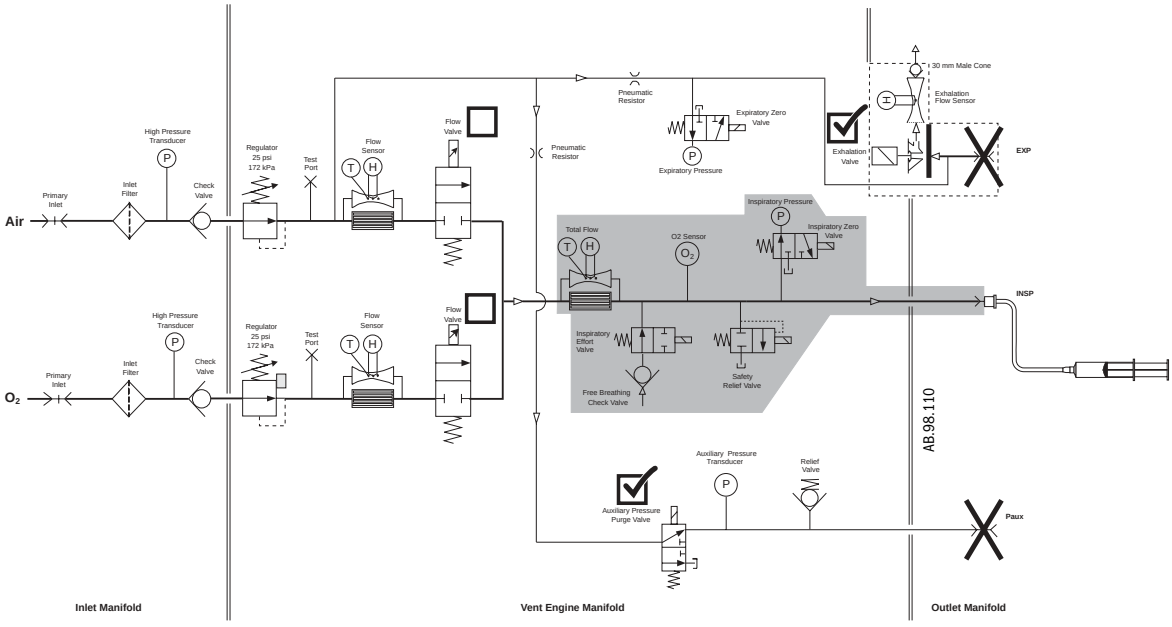
- either if unable to build 70 cmH_2O pressure,
- or if the leak rate exceeds 10 ml/min,

the following steps will help to narrow down the possible leak locations.

While retaining the leak test setup:

1. Close the Air and O_2 flow valves to limit the components tested (remove the checkmarks from the boxes next to the DAC counts).
2. Repeat the Vent Engine Leak Test.
   - If the test passes, proceed to step 5.
   - If the leak remains, toggle the Effort Valve closed.
3. Repeat the Vent Engine Leak Test.
   - If the system passes, check the Free Breathing Valve diaphram and o-ring seal.
   - If the leak remains, toggle the safety valve open/closed.
4. Repeat the Vent Engine Leak Test.
   - If the system passes, check the safety valve seal.
   - If the leak remains, check the individual components in the Total Flow path.




Air
O2
Primary Inlet
Inlet Filter
High Pressure Transducer
Check Valve
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.110
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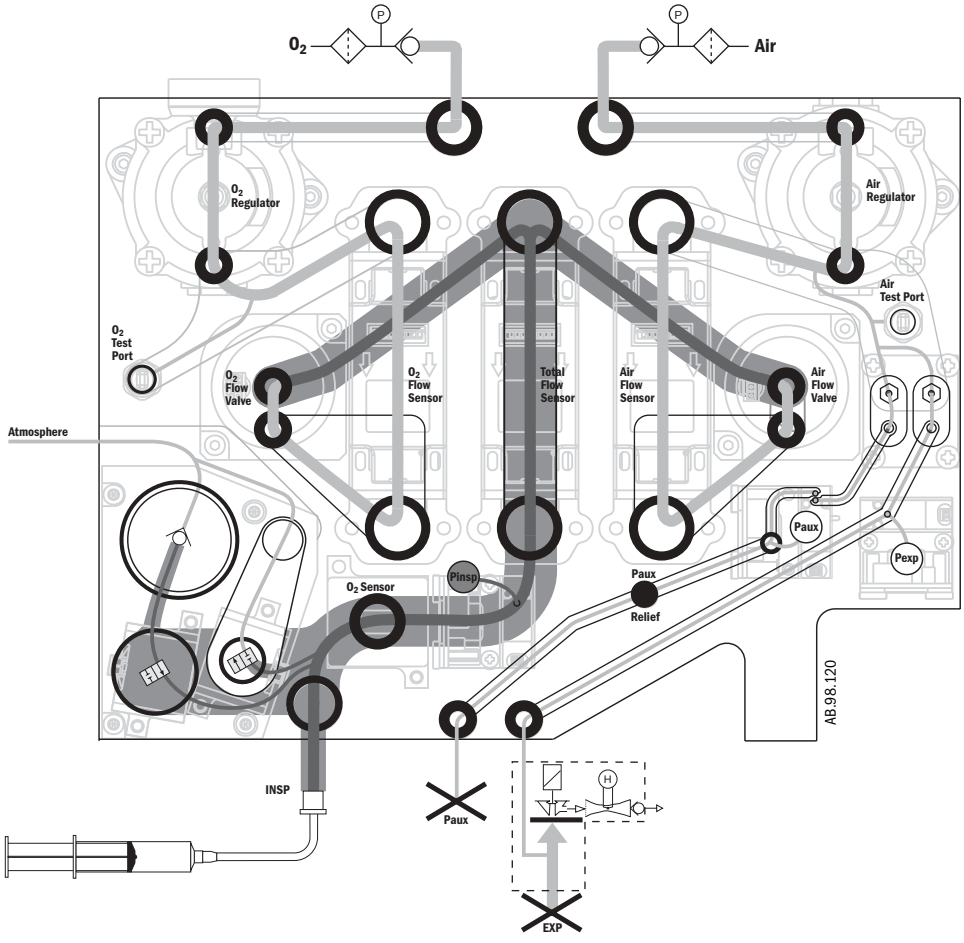
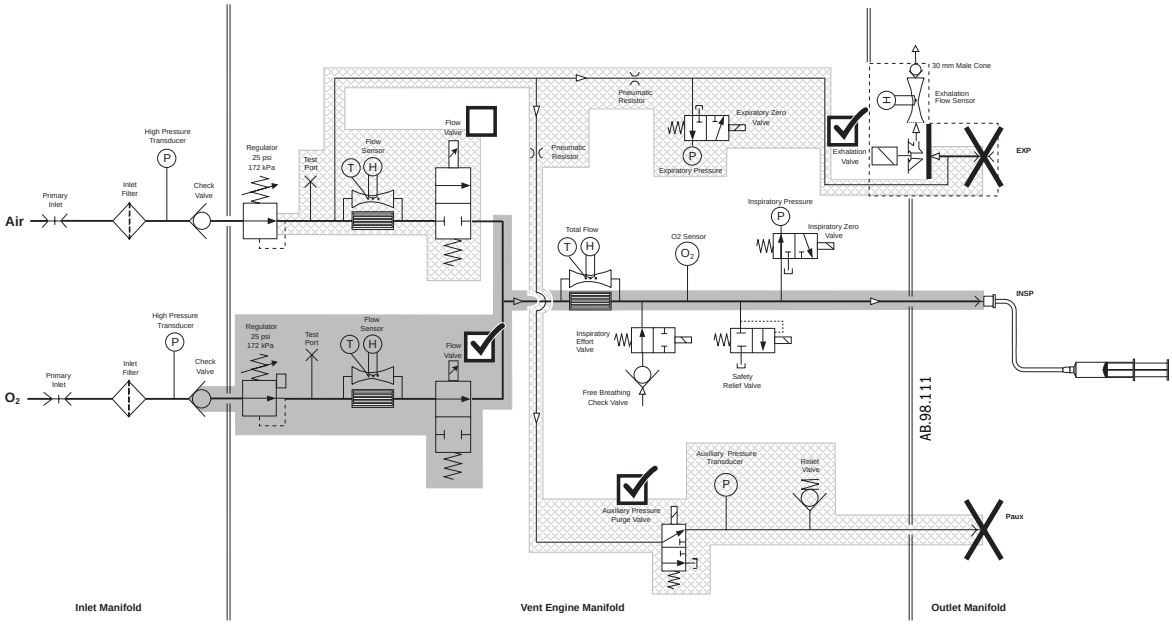
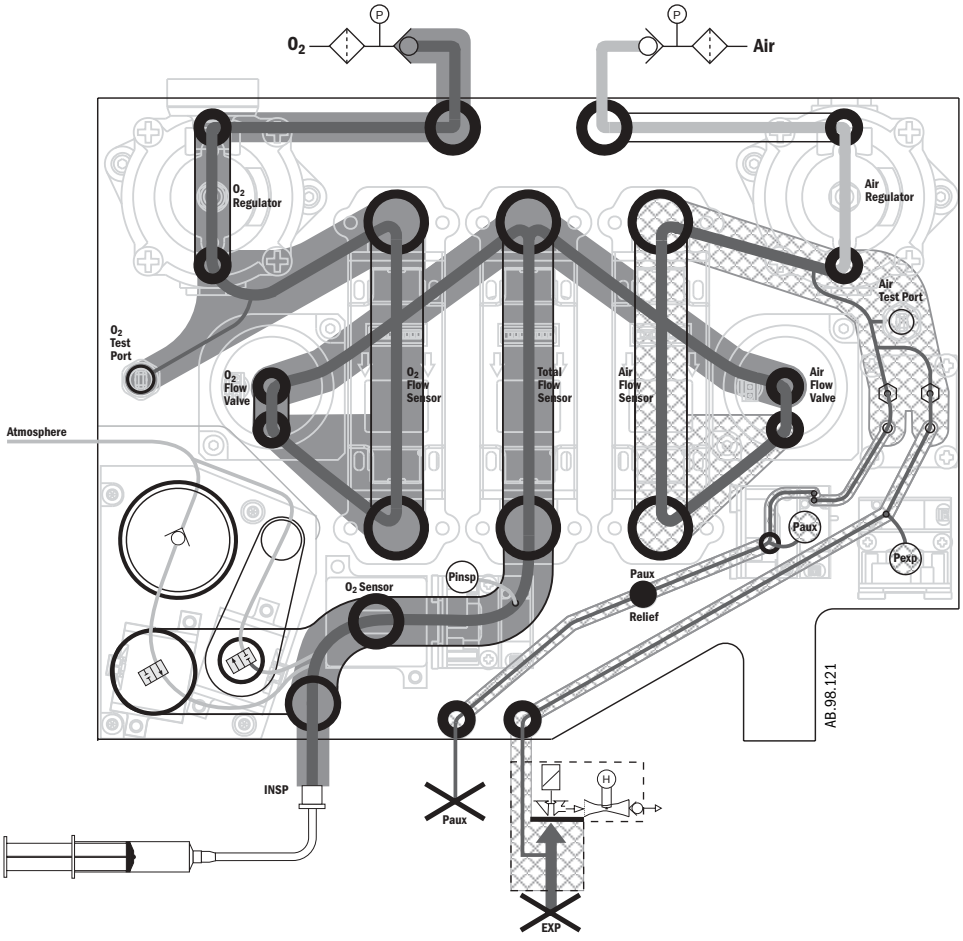
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


O2
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Relief
AB.98.120
INSP
EXP

5. Open only the O_2 flow valve by checking the ***O2 Flow Valve*** box (verify that 60000 DAC counts are set).
6. Repeat the Vent Engine Leak Test.
   - If the test fails, check the individual components in the O_2 Flow path.
   - If the test passes, check the individual components in the Air Flow path.


Air
O2
Primary Inlet
Inlet Filter
High Pressure Transducer
Check Valve
Regulator 25 psi 172 kPa
Test Port
Flow Sensor
Flow Valve
Pneumatic Resistor
Expiratory Zero Valve
Expiratory Pressure
30 mm Male Cone
Exhalation Flow Sensor
Exhalation Valve
EXP
Inspiratory Pressure
Inspiratory Zero Valve
Total Flow
O2 Sensor
INSP
Inspiratory Effort Valve
Free Breathing Check Valve
Safety Relief Valve
AB.98.111
Auxiliary Pressure Transducer
Relief Valve
Auxiliary Pressure Purge Valve
Paux
Inlet Manifold
Vent Engine Manifold
Outlet Manifold


O2
Air
O2 Regulator
Air Regulator
Air Test Port
O2 Test Port
O2 Flow Valve
O2 Flow Sensor
Total Flow Sensor
Air Flow Sensor
Air Flow Valve
Atmosphere
Paux
Pexp
Pinsp
O2 Sensor
Paux Relief
AB.98.121
INSP
Paux
EXP

7.3 Alarm message troubleshooting chart

Note: Whenever "Check/replace harness" is indicated, ensure that all terminals are fully inserted into the connector body window and that all wires are properly crimped.

Troubleshooting guidelines are listed in order of probability. The entire list does not need to be carried out if the problem is resolved. The list may not include all possible solutions.

- Alarm message = display message
- Alarm ID = message in Error log or Event log

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
-none-	DU RAM Error	Failed	Self test failure or multi bit error detected.	Run Backup Ventilation if in Therapy.
-none-	Therapy Power Off	High	Power switch is set to Off.	
• Normal operation if On/Standby switch is moved to standby while in therapy. • Verify vent is in standby state prior to turning power On/Standby switch to standby. • Check/replace harness to On/Standby switch. • Check/replace On/Standby switch. • Check/replace PMB.				
Air supply pressure high	Air Supply Pres High	Low	Air supply pressure > 95 psig for more than 0.5 seconds	
• Check air supply. • Disconnect sensor and verify output is zero gauge pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, replace supply pressure sensor. • If not, check/replace VMB.				
Air supply pressure low Flow Wave: O2 only	Air Supply Pres Low	Medium	Air supply pressure < 24.3 psig for more than 0.5 seconds	Unit shuts down Air supply and delivers 100% Oxygen
• Check air supply. • Disconnect sensor and verify output is zero gauge pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, check/replace harness. • If not harness, check/replace VMB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Air temp high Flow Wave: O2 only	Temp High	High	Total flow sensor temperature ≥ 48 C	Switch to 100% O2. Air is turned off regardless of other alarm conditions (for example, O2 Supply Low). When the condition clears, the vent changes back to previous known good set O2 mixture.
	• Check inlet air temperature. • Use Service App to check temperatures of air and total flow sensors. • If inlet air temp is NOT high, and if temp from total flow sensor reports more than 9°C higher than the air sensor, replace Total Flow Sensor. • With a air flow of approximately 10 l/min, verify air and total flows are within 10% of each other.			
Air temp sensor error	Air Temperature Sensor Failure	Low	Out of range air temperature sensor data (range is 0-60 degrees C).	Use total flow temperature for all air flow sensor calculations, including alarms. If total flow sensor temperature not available, use 50°C.
	• Check inlet air temperature. • If **comm. Failure** alarm is also active, check harness connections. • With gas supplies disconnected and system temperature stabilized, use Service App to check temperatures of air and total flow sensors. Air flow sensor and total flow sensor shall not differ by more than 9°C. • Replace sensors.			
Backup audio failure	Backup Buzzer POST	Medium	Current to buzzer indicates audio is not sounding.	This alarm is logged at start-up and can be de-escalated but cannot be cleared from the screen.
	• Check harness connection between PMB/On-Standby switch. • Verify buzzer current with voltage measurement at TP15 on VCB. If voltage IS NOT present, replace PMB. If voltage IS present, replace VCB.			
Backup mode active	Backup Mode Active	Medium	Spontaneous breathing is insufficient or Display Unit failure. System goes into Backup Ventilation mode.	Uses PCV mode and preset settings (customer configurable).
	• Ensure the patient's spontaneous breathing and ventilatory support is adequate. This alarm could be triggered by user errors regarding patient ventilation requirements. See URM for details. • Check error log for communication errors or DU errors.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Check D-fend CO2 or O2 wave instruction: Check D-fend. Wait 30 sec and press Normal Screen to continue.	MGAS Sample Line Not Connected >40 Sec	Medium	MGAS communicates the sample tubing or the D-fend module is not installed.	The pump turns Off. If Normal Screen is selected the DU commands the MGAS to start sampling again.
• Check that the sample tube is connected. • Check that the water trap is connected. • Check that the gas outlet is not blocked. • Replace Module.				
Check sample gas out CO2 or O2 waveform instruction: Check sample gas out. Wait 30 sec and press Normal Screen to continue.	MGAS Check Sample Gas Out > 20 Sec	Medium	MGAS communicates continuous occlusion for 20 seconds	The pump turns Off. If Normal Screen is selected, the DU commands the MGAS to start sampling again.
• Check the gas outlet. • Replace module.				
Connect nebulizer	Nebulizer not Connected	Low	Nebulizer disconnected while nebulization procedure is running.	
• Re-connect Nebulizer. • Replace Nebulizer cable. • Replace Nebulizer head. • Replace Nebulizer board.				
Controls frozen. Need service	Front Panel Com Fail	High	Key pad controller fails to send life tick for greater than 10 seconds	DU to allow power off confirmation, even in Therapy. *(The Power lock popup will not appear.)*
• Cycle power • Replace Keypad Controller				
Exp flow sensor failure	Exhalation Flow Sensor Communications Failure	High	Failed communications with exhalation flow sensor.	Use open loop pressure control.
• Check harness connection between VMB and exhalation flow sensor PCB. • Replace exhalation flow sensor PCB. • Replace VMB.				
Fans require service	Fan Fail	Medium	Fan Power Status Bits for main fan or vicor fan is low.	
• Check connections to fans. • Replace broken fan(s).				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
FiO2 control error	Air Flow Sensor Communications Failure	Medium	Loss of communication.	Use Open Loop valve mixture control. Return to closed loop volume delivery control when cleared.
• Check Error Log for Air/O2 Insp Flow Sensor Supply Voltage. • If yes: -Disconnect vent engine harness at air flow sensor. If voltage error stops, replace air flow sensor. -Disconnect vent engine harness at O2 flow sensor. If voltage error stops, replace O2 flow sensor. -Disconnect vent engine harness at VCB. If voltage error stops, replace harness. • If no: -Check connection to Air Flow Sensor. -Interchange harness connection between air and total flow sensor. -If problem stays with sensor, replace sensor. If alarm follows harness, check/replace harness. If harness is OK, replace VCB.				
FiO2 control error	O2 Flow Sensor Communications Failure	Medium	Loss of communication.	Use Open Loop valve mixture control. Return to closed loop volume delivery control when cleared.
• Check Error Log for Air/O2 Insp Flow Sensor Supply Voltage. • If yes: -Disconnect vent engine harness at air flow sensor. If voltage error stops, replace air flow sensor. -Disconnect vent engine harness at O2 flow sensor. If voltage error stops, replace O2 flow sensor. -Disconnect vent engine harness at VCB. If voltage error stops, replace harness. • If no: -Check connection to O2 Flow Sensor. -Interchange harness connection between O2 and total flow sensor. -If problem stays with sensor, replace sensor. If alarm follows harness, check/replace harness. If harness is OK, replace VCB.				
Flow sensor error	Exhalation Flow Sensor Comparison	Medium	(TVexp – TVinsp) > (0.3* TVinsp) or 100 mL whichever is greater for 6 consecutive breaths.	Freeze vent engine volume compensation on first breath detected.
• Using Service App, verify Inspiratory flows match Expiratory flow within tolerance stated above. • Replace expiratory sensor as necessary. • Replace exhalation flow sensor board (EFSB).				
Internal power failure	PMB DC-DC Fail	Medium	AC supply is OK but batteries are being discharged.	
• Check screw terminal connections and harness between AC-DC power supply and PMB • Check fuse F1. If not OK, replace PMB. • Replace AC-DC power supply.				
Mixed gas temp sensor error	Total Flow Temperature Sensor Failure	Low	Out of range total temperature sensor data.	Use air flow temperature for total flow sensor calculations, including alarms. If air flow sensor temperature not available use 50°C.
• Check inlet air temperature. • If **comm. Failure** alarm is also active, check harness connections. • With gas supplies disconnected and system temperature stabilized, use Service App to check temperatures of air and total flow sensors. If either reports temperature out of range (0 to 60°C), replace that sensor.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Module fail. No CO2, O2 data	MGAS Sensor Inop > XX	Medium	MGAS communicates hardware failure (RAM failure, ROM checksum error, Error in CPU EEPROM, Error O2 preamp EEPROM, Error in SSSboard EEPROM, Voltage error, or Lamp control failure.)	
• Replace Module				
Module not compatible	Module Not Compatible	Low	The monitoring module detected is not compatible with system software. The EV is designed to work with the following Compact Airway Modules: SW Version 3.2 and above of M-C, M-CO, M-COV, M-COVX, M-CAiO, M-CAiOV, and M-CAiOVX.	
• Remove and reseat Module. • Check software revision in the Service Log. • Replace Module.				
Negative airway pressure	Negative Pressure	High	Paw insp or Paw exp < -10 cmH20	Latched alarm. PEEP numeric highlighted in red.
• Compare Insp and Exp sensor values using the Service App at zero and 100 cm/H2O. The Insp and Exp pressure sensors should match within ±5 cmH20 (while at 0 cmH2O true pressure) and ±10 cmH2O (while at 100 cmH20 true pressure) • Calibrate pressure sensors. • Refer to pneumatic troubleshooting section for testing zeroing valve. • Check harness connection on VCB and VMB. • Replace sensor as needed.				
No battery backup	Degraded Battery	Medium	The total battery voltage is <20VDC -or- Each battery voltage is <10VDC	
• Verify unit has been connected to mains for more than 24 hours. • Check error log for related messages. • Use Service App to determine charge state. If in trickle charge, replace batteries. • Check/replace harness. • Check/replace PMB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
No battery backup?	DU to PMB Com Error -or- PMB to DU Com Error	Medium	Communications from the DU to the power controller cannot be established for 10 seconds. -or- Communications from the power controller to the DC cannot be established for 10 seconds.	PMB assumes failed state and allows system to shutdown without confirmation from DU. (This alarm allows vent to be shut down if DU communications is lost.) Note question mark at end of message and no battery status indicator on display.
• Check error logs for related messages. • Check communication (no software information indicates no communication). • If multiple failures, replace DU CPU board. • Check / replace display cable. • Check (reseat) all connections on all PC boards. • Check/replace DU interface board. • Replace motherboard. • Replace PMB.				
No battery backup?	PMB POST Failure	Medium	Power controller failed CPU self tests	Note question mark at end of message and no battery status indicator on display
• Cycle power. • Replace PMB.				
No battery backup	Battery Charge Fail -or- Standby Current High	Medium	The system is powered on with a battery current >1.3 amps. -or- System is in Standby and the charge current is >1.7 Amps.	
• Cycle power. • Check/replace harness. • Replace Power Supply. • Replace PMB.				
No battery backup	Battery Fail	Medium	While bulk, over, or float charging any battery is <10.5VDC (short) -or- Battery has been charging for >24h while powered on (sulfated) -or- Voltage >16.5V during bulk or over charging and normal current >0.25 amps (sulfated).	Battery status indicator appears under clock.
• Cycle power. • Check/replace harness. • Replace batteries.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
No battery backup	Battery Missing	Medium	Any battery voltage is between -1.0 and +1.0VDC.	Battery status indicator appears under clock.
• Cycle power. • Check connections/replace harness. • Check/replace fuse. • Replace batteries.				
No battery backup	Battery Reversed Connection	Medium	Any battery voltage is less than -1.0VDC	Battery status indicator appears under clock.
• Cycle power. • Check connections to battery. • Replace batteries. • Replace PMB.				
No battery backup	Self Test Fail	Medium	Power controller failed self tests (memory, voltages, or CPU).	Battery status indicator appears under clock.
• Cycle power. • Replace PMB				
No battery backup	Standby Bulk Charge > 12Hrs	Medium	System is in Standby and the charge mode is bulk charging and the duration has exceeded 12 hours.	
• Check connections • Replace batteries. • Replace PMB.				
No exp flow sensor	No Exhal Flow Sensor	High	No Exhalation Flow Sensor connected	Use Open Loop pressure control.
• Check Exhalation flow sensor connection. • Replace Exhalation Flow Sensor. • Verify low pressure leak test passes. • Check/replace interface PCB and flex circuit. • Check/replace exhalation flow sensor PCB.				
No gas supply pressure	No Supply Pressure	High	O2 supply pressure and air supply pressure < 24.3 psig for more than 0.5 seconds	Continue 100% gas flow of whichever gas has the higher pressure value at the onset of the alarm; if both are equal, use 100% O2.
• Check O2 and Air supply pressures. • Check/replace harness between sensor and VMB. • Check error log for reference voltage errors. • Check/replace VMB.				
O2 sensor failure	O2 Sensor Fail	Medium	Out of range O2 sensor (Paracube) data greater than 103% or communication error	
• Calibrate O2 sensor with Checkout (ensure both Air and O2 gas supply are connected). • Calibrate O2 sensor with Service App (ensure both Air and O2 gas supply are connected). • Verify O2 Concentration sensor voltage error is not present in error log. • Check/replace harness. • Check/replace O2 sensor. • Check/replace VMB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
O2 supply pressure high	O2 Supply Pres High	Low	O2 supply pressure > 95 psig for more than 0.5 seconds	
	• Check O2 supply. • Disconnect sensor and verify output is zero gage pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, replace supply pressure sensor. • If not, check/replace harness. • If not harness, check/replace VMB.			
O2 supply pressure low Flow Wave: Air only	O2 Supply Pres Low	Medium	O2 supply pressure < 24.3 psig for more than 0.5 seconds	Latched De-escalatable Go to 100% Air.
	• Check O2 supply. • Disconnect sensor and verify output is zero gauge pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, check/replace harness. • If not harness, replace VMB.			
O2 temp sensor error	O2 Temperature Sensor Failure	Low	Out of range O2 temperature sensor data. (range is 0-60 degrees C)	
	• Check inlet O2 temperature. • If **comm. Failure** alarm is also active, check harness connections. • With gas supplies disconnected and system temperature stabilized, use Service App to check temperatures of O2 and total flow sensors. O2 flow sensor and total flow sensor shall not differ by more than 9°C. • Replace sensors.			
On battery	Low Internal Battery – 30 Min	Medium	Mains power not available. Internal battery supply < 30 minutes calculated via battery discharge algorithm.	
On battery	On Battery	Medium	Mains power not available. System powered by internal battery for more than 300 ms.	
	• Normal alarm if system is operating on battery. • Check connection to AC supply (verify green LED on DU is lit). • If LED is not lit, check AC mains source, check rear power cord clamp, check fuses. • If LED is lit, check output of DC power supply at screw terminals. Range is 20-32 V. If out of range, disconnect DC power supply input harness and verify output is still out of range. Check/replace DC power supply input harness. If out of range and harness is OK, replace DC power supply. • Measure voltage at F1 (both sides) on PMB. Range is 20-32V. • Check/replace fuse F1 on PMB. • Replace PMB.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Pair sensor out of range	Air Supply Pressure Sensor Out of Range	Low	Out of range Air supply pressure sensor data. Range is 195 to 4760 mV	
	• Check Air supply • Disconnect sensor and verify output is zero gage pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, check/replace harness. • If harness OK, replace VMB.			
Patient connected?	Standby Patient Detection	High	Paw insp or Paw exp > 3 cmH2O when bias flow set to 3 l/min air or O2 (if Air not available) and exhalation valve set to 6 cmH2O for 3 seconds.	Non-silencable Audible in Standby and Monitoring states. When placed in Standby state either by the user or after power up, the ventilator will maintain a bias flow so as to detect if a patient has been attached to the circuit. This functionality alerts for an inadvertent attachment of the patient without the user actuating ventilation.
	• Was patient connected during standby state? If yes, this is a user error. If no: • Remove all tube connections from vent. If alarm persists, check exhalation pressure port and exhalation valve housing. • Calibrate Flow control valves. • Calibrate airway pressure transducers. • Using the Service App and occluded circuit, set 3 l/min flow, and set 6 cmH2O on exh. Valve. Ensure both Insp and Exp pressure sensors read 6 ±3 cmH2O. Open circuit and verify pressure is < 2 cmH2O. • Check/replace zero valves. • Replace appropriate pressure sensor board. • Replace appropriate flow control valve.			
Paux high	Paux High	Low	Paux > 100 cmH2O	De-energize Paux purge valve (if purge valve is energized) until alarm condition clears.
	• Verify Paux port (and any tubing that is connected to Paux port) is not occluded when purge valve is energized (purge is turned ON). • Zero Paux pressure sensor. • Use the Service App to calibrate the Paux pressure sensor (Section 5.2.7). • Interchange Paux and Pexp connections. If Paux high alarm stops, replace Paux sensor. • If Paux High alarm continues, replace VCB.			
Paux sensor out of range	Paux Sensor out of range	Low	Paux sensor data out of range. Range: 10-4095 mV	
	• Check/replace harness. • Interchange Paux and Pexp connections. If Paux alarm stops, replace Paux sensor. • If Paux alarm continues, replace VCB			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Paux sensor out of range	Paux Zeroing Error	Low	Range for zero pressure: 631-966 mV (counts)	If failed, use previous known good offset value for Paux.
• Verify Paux port (and any tubing that is connected to Paux port) is not occluded when purge valve is energized (Purge is turned ON). • Zero Paux pressure sensor. • Check/replace harness. • Interchange Paux and Pexp connections. If Paux alarm stops, replace Paux sensor. • If Paux alarm continues, replace VCB				
Pbaro sensor out of range	Barometric Pressure Sensor Out of Range	Low	Out of range barometric pressure data. Range: 2163-4340 mV	The EV will use the entered altitude setting to determine the calculated barometric pressure value.
• Calibrate the barometric sensor (refer to Section 8.7.4). • Replace VMB (recalibrate barometric sensor).				
Pexp sensor out of range	Paw exp Sensor Out of Range	High	Out of range Paw exp sensor data. Range: 10-4095 mV	
• Check/replace harness. • Interchange Paux and Pexp connections. If Pexp alarm stops, replace Pexp sensor. • If Pexp alarm continues, replace VMB.				
Pexp sensor out of range	Paw exp Zeroing Error	Low	Range for zero pressure: 631-966 mV (counts)	If failed, vent uses previous known good offset value for Paw exp
• Verify Pexp port is not occluded. • Zero Pexp pressure sensor. • Check/replace zeroing valve. • Check/replace harness. • Interchange Paux and Pexp connections. If Pexp alarm stops, replace Pexp sensor. • If Pexp alarm continues, replace VMB.				
Pinsp sensor out of range	Paw insp Sensor Out of Range	High	Out of range Paw exp sensor data. Range: 10-4095 mV	
• Check/replace harness. • Interchange Paux and Pinsp connections. If Pinsp alarm stops, replace Pinsp sensor. • If Pinsp alarm continues, replace VCB				
Pinsp sensor out of range	Paw insp Zeroing Error	Low	Range for zero pressure: 631-966 mV (counts)	If failed, vent uses previous known good offset value for Paw insp.
• Zero Pinsp pressure sensor. • Check/replace zeroing valve. • Check/replace harness. • Interchange Paux and Pinsp connections. If Pinsp alarm stops, replace Pinsp sensor. • If Pinsp alarm continues, replace VCB.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
PO2 sensor out of range	O2 Supply Pressure Sensor Out of Range	Low	Out of range O2 supply pressure sensor data. Range is 195 to 4760 mV	
	• Check O2 supply. • Disconnect sensor and verify output is zero gage pressure. • Interchange harness connections on both supply pressure sensors. • If alarm follows the sensor, check sensor connector terminals. Replace supply pressure sensor if necessary. • If not, then check/replace harness. • If not harness, then replace VMB			
Pressure sensor failure	Paw Cross- Check	High	Paw exp – Paw insp > 10 cmH2O for more than 100 ms	
	• Verify Pexp port is not occluded. • Check airway pressure transducer calibration(s) at 0, 50, and 100cmH2O. Calibrate if necessary. • Check/replace zeroing valve(s). • Check/replace harness. • Check/replace pressure transducer(s). • Check/replace VCB or VMB.			
Primary audio failure	Alarm Confirm Error	High	If the DU detects a speaker current sense bit false when attempting to sound the speaker.	Audible in Standby and Monitoring. De-escalates to Low priority. VCB/VMB will receive data from DU indicating: 1) High priority alarm successfully sounded. 2) High priority alarm not successfully sounded. 3) No High priority alarm currently active. The VMB or VCB will activate the backup buzzer when condition 2 in the special behavior column is active or if condition 1 in the special behavior column is not detected within 15 seconds of the VCB or VMB issuing A high priority alarm. (All high priority alarms that have the VCB or VMB as the source will activate this alarm.)
	• Adjust speaker volume to its highest volume. If alarm stops, replace DU speaker. • Check DU speaker connection. • Replace speaker. • Replace DU CPU board.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
Relief valve failure Paw and Flow Wave: Ventilation not available	Safety Valve Checkout Failure	High	Failed Safety Relief Valve Checkout	User cannot enter Therapy state after a powerup until removal criteria is met.
	• Check for pneumatic leaks. • Verify seat/seal interface is clean. • Verify safety valve relief port (bottom of ventilator) is not blocked. • Perform the *Mechanical over-pressure valve test* (Section 5.2.11). Removal requires successful checkout.			
Replace D-fend CO2 or O2 wave: Replace D-fend	MGAS Inlet Filter Residue >40 Sec	Medium	MGAS communicates: Residue buildup on the water trap membrane. This decreases airflow.	De-escalatable. The pump turns Off. If a Normal Screen push is detected, the DU commands the MGAS to start sampling again.
	• Replace D-fend.			
Sample line blocked CO2 or O2 waveform instruction: Continuous blockage. Check sample line and D–fend. Wait 30 seconds and press Normal Screen to continue.	MGAS Line Blocked >20 Sec	Medium	MGAS communicates: The sample tubing inside or outside the monitor blocked, or the water trap is occluded.	De-escalatable. The pump turns Off. If a Normal Screen push is detected, the DU commands the MGAS to start sampling again.
	• Replace the sample line. • Replace D-fend.			

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Failed State message: **System failure.** **Service required**	DU to VCB Com Error	Failed	Proper communications from the DU to the VCB is not successfully completed within a 10 second window.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VMB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VCB is fully inserted into mother board. -Verify yellow VCB communications activity indicator CR16 (RX DU) is lit and blinking. If not blinking: -Replace VCB. -Check/replace motherboard. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board.				
Failed State message: **System failure.** **Service required**	DU to VMB Com Error	Failed	Proper communications from the DU to the VMB is not successfully completed within a 10 second window. Note: Timing does not start for 90 seconds after power up.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VCB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VMB is fully inserted into motherboard. -Replace VMB. -Check/replace motherboard. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Failed State message: **System failure. Service required**	Processor Reset	Failed	Sequential watchdogs cause a processor reset on either VCB or VMB.	Vent Safe Operation. This requirement is intended to ensure that a SW or watchdog reset (indicating loss of processor control) of either the VCB or VMB will activate the backup audio alarm.
• Cycle power. • Using service card, check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VCB and VMB. • If no VCB comm., check VCB CR10 red reset indicators. If lit, replace VCB. • If no VMB comm., check VMB CR10 red reset indicators. If lit, replace VMB.				
Failed State message: **System failure. Service required**	VCB to DU Com Error	Failed	Proper communications from the VCB to the DU is not successfully completed within a 10 second window. **Note**: Timing does not start for 90 seconds after power up.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VMB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VCB is fully inserted into mother board. -Verify yellow VCB communications activity indicator CR15 (TX DU) is lit and blinking. If not blinking: -Replace VCB. -Check/replace motherboard. -Check/replace DU CPU board.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
• **Action/Troubleshooting**				
Failed State message: **System failure.** **Service required**	VMB to DU Com Error	Failed	Proper communications from the VMB to the DU is not successfully completed within a 10 second window. **Note**: Timing does not start for 90 seconds after power up.	Run Backup Ventilation if in Therapy.
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Using service card, check DU communication to VCB. • If multiple subsystem communication failures: -Check/replace DU cable. -Verify DU system interface PCB is fully inserted into DU CPU PCB. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board. • If not multiple subsystem communication failures: -Check/replace DU cable -Verify VMB is fully inserted into mother board. -Replace VMB. -Check/replace motherboard. -Check/replace DU system interface PCB (connector panel assembly). -Check/replace DU CPU board.				
Failed State message: **System failure.** **Service required**	VMB to VCB Com Error	Failed	Proper communication of the high speed sensor data from the VMB to the VCB is not successfully completed within a 50 ms window.	
• Cycle power. • Check error log for underlying causes such as voltage range errors. • Check DU/VMB and DU/VCB communication using Service Card. • Verify VMB and VCB are fully inserted into motherboard. • Check/replace VMB. • Check/replace VCB. • Check/replace motherboard.				

Alarm message	Alarm ID	Priority	Alarm Condition	Special Behavior/Comments
	• **Action/Troubleshooting**			
System shutdown in <20 min.	Low Internal Battery – 20 Min	Medium	Mains power not available. Internal battery supply < 20 minutes calculated via battery discharge algorithm.	
System shutdown in <10 min	Low Internal Battery – 10 Min	High	Mains power not available. Internal battery supply < 10 minutes calculated via battery discharge algorithm	
System shutdown in <5 min	Low Internal Battery – 5 Min	High	Mains power not available Internal battery supply < 5 minutes calculated via battery discharge algorithm	
System shutdown in <1 min	Low Internal Battery – 1 Min	High	Mains power not available. Internal battery supply < 1 minute calculated via battery discharge algorithm	
	• Normal alarm if system is operating on battery. • Check connection to AC supply (verify green LED on DU is lit). • If LED is not lit, check AC mains source, check rear power cord clamp, check fuses. • If LED is lit, check output of DC power supply at screw terminals. Range is 20-32 V. If out of range, disconnect DC power supply input harness and verify output is still out of range. Check/replace DC power supply input harness. If out of range and harness is OK, replace DC power supply. • Measure voltage at F1 (both sides) on PMB. Range is 20-32V. • Check/replace fuse F1 on PMB. • Replace PMB			
Temp high. Shutdown possible Paw Wave Instruction: Check fan filter.	Power Supply Temp High	High	Vicor power supply temperature exceeds 75°C	
	• Check main fan filter. • Check/replace fans. • Check error log/power diagnostics for underlying causes such as fan failure indicators or voltage range errors. • Verify ambient is < 40 degrees C. • Replace PMB			
Volume delivery error	Total Flow Sensor Communications Failure	Medium	Out of range total flow sensor data -or- Loss of communication.	Return to closed loop volume delivery control when cleared.
	• Check Error Log for Total Flow Sensor Supply Voltage. -If yes: - Disconnect harness at flow sensor. If voltage error stops, replace flow sensor. -Disconnect vent engine harness at VCB. If voltage error stops, replace harness. • If no: -Check connection to Total Flow Sensor. -Interchange harness connection between air and total flow sensor. -If this alarm stops, replace total flow sensor. If this alarm persists, check/replace harness. If harness is OK, replace VCB.			

7.4 Troubleshooting Service App messages

The VCB Service App screen includes a ***Calibrations and Tests*** section (Section 8.6.5). This section includes a field "*Calibration Running*" that displays messages while a test is in progress. Some messages indicate that the test encountered a problem. Use the following table to help troubleshoot messages that result in a failed test or calibration.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Aborted	Calibration or test in progress has been aborted.	None
Air Flow Sensor Chk	Air Flow Sensor Chk	None
Air Flush Time: *value sec*	*Value* = time (sec) needed to flush system with Air until stability of 0.1% O_2 is reached.	None
Air Sensor Check Passed	Air Sensor Check passed.	None
Air Valve Cal OK	Air Valve Cal passed.	None
Aux Span Counts: *value*	Auxiliary pressure sensor DAC counts that correspond to 100 cmH_2O. (range: 3026 to 3589)	None
Aux Zero Fail: *value*	Auxiliary pressure sensor zero DAC is out of range. *Value* = measured zero DAC (normal range = 631 to 968)	1. Verify ***Paux*** port is open to atmosphere (either directly or via open tube). 2. Replace zero valve. 3. Replace pressure transducer.
Bad Air Flow	Not able to achieve proper open loop flow during exhalation valve calibration. Set at 4 L/min.	1. Verify FCV is opening to give flow. Should be at least 2 L/min. If no flow, replace FCV.
Bad Air/Total Flow Status	This message will appear if there is a problem with one of the flow sensors during the regulator step test.	Check flow sensor connections. Test by setting up gas flows using the Service App.
Bad Low Pressure: *value*	Lowest pressure achieved during exhalation valve cal > 2.5 cmH_2O. *Value* = lowest pressure achieved in cmH_2Ox100	1. Verify exhalation valve assembly is properly assembled and latched to outlet manifold. 2. Verify tube connecting Insp port to Exp port is not occluded/kinked.
Bad O2 Flow	Not able to achieve proper open loop flow during exhalation valve calibration. Set at 4 L/min.	1. Verify FCV is opening to give flow. Should be at least 2 L/min. If no flow, replace FCV.
Bad O2/Total Flow Status	This message will appear if there is a problem with one of the flow sensors during the regulator step test.	Check flow sensor connections. Test by setting up gas flows using the Service App.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Baro Check Passed	Barometric pressure checkout passed.	None
Barometric Chk	Barometric pressure sensor check in progress.	None
Barometric Fail	During Barometric pressure check, barometric pressure sensor and calculated baro pressure from set altitude differ by more than 20% of calculated baro pressure.	Refer to Section 7.1.2.
Calibrating Flow Valve	Calibrating Flow Valve.	None
Can't Achieve 100cmH2O	Exhalation valve calibration can not generate 100 cmH_2O pressure in the breathing circuit.	1. Verify flow > 1 L/min from FCV. Recal if necessary. 2. Verify breathing circuit is connected and not leaking. 3. Verify low pressure vent engine system is not leaking. 4. Verify clean exhalation housing seat/seal. Replace parts as necessary. 5. Verify power to exhalation valve actuator. 6. Check/replace harness. 7. Replace VCB.
Can't Extrapolate Table	During flow valve calibration, if a weak or restricted gas supply pressure requires the 140 or 160 L/min points to be extrapolated and the calculated value is > 65,000 DAC counts, this message comes up. This results in maximum flow limited to whatever is the highest flow point in the calibration table.	Check for a weak or restricted gas supply pressure.
Can't Pressurize: *value*	During Paw transducer check, the breathing circuit could not reach 33 cmH_2O. During Relief Valve check, the breathing circuit could not reach 30 cmH_2O. During Exh Valve Cal Check, the exp pressure does not stabilize within 0.1 cmH_2O within 12 seconds. *value* = max exp pressure achieved.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Can't Pressurize1: *value*	During 1st half of Low Pressure leak check, the breathing circuit could not reach 34 cmH_2O. *value* = max exp pressure achieved.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Can't Pressurize2: *value*	During 2nd half of Low Pressure leak check, the breathing circuit could not reach 25 cmH2O. *value* = max exp pressure achieved.	1. Verify breathing circuit is connected and not leaking. 2. Verify low pressure vent engine system is not leaking. 3. Verify exhalation valve is properly connected and all seals are in place. 4. Verify gas flow from flow control valves. Recal if necessary.
Checking supply press1	During FCV calibration, the source and integrity of the gas supply (compressor or wall supply) is being tested.	None; normal operation.
Checking supply press2	During FCV calibration, the source and integrity of the gas supply (compressor or wall supply) is being tested.	None; normal operation.
Checkout Aborted	Checkout Aborted	None
Checkout Done	Checkout Done	None
Disagree Temp: *value*	During Air (or O_2) flow sensor check, air flow sensor temp is more than 9 ˚C different than total flow sensor temp. *Value* = temperature difference (˚C)	1. If only one flow check fails, replace that flow sensor. 2. If both Air and O_2 flow check fails, replace total flow sensor.
Disagree Tot: *value1* Air: *value2*	During air flow sensor check, air flow sensor is more than 15% different than total flow sensor at a nominal flow of 30 L/min. *Value1* = measured total flow. *Value2* = measured air flow.	Check regulator for oscillation. Replace if necessary.
End Pressure: *value*	Exhalation valve check: *Value* = time required to relieve pressure in system from 34 cmH_2O to less than 2 cmH2O. Must be less than 250 msec to pass.	Refer to Section 7.1.5.
Exh Flow Check Passed	Exhalation Flow Check passed.	None
Exh Flow Sensor Chk	Exhalation flow sensor check in progress.	None
Exh Valve Cal	Exhalation valve calibration in progress.	None

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Exh Valve Cal Chk	Exhalation valve check in progress.	None
Exh Valve Cal OK	Exhalation valve calibration passed.	None
Exh Valve Check Passed	Exhalation Valve Check Passed.	None
Exp Flow Cal	Expiratory flow sensor calibration in progress.	None
Fail No 120 Min: *value*	Flow valve cal timeout: never made it to 1 20 L/min of flow during flow valve cal.	Check for weak or restricted gas pressure supply.
Failed 120lpm flow: *value*	During FCV calibration - could not hold 1 20 L/min flow for 1 second before supply pressure drops below 30 psi.	Check for weak or restricted gas pressure supply.
Failed Supply Press: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press2: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press3: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press4: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press5: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press6: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press7: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press8: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Failed Supply Press9: *value*	During FCV calibration - inadequate supply pressure.	Check gas supply source to see if it is too weak or restricted.
Flow Diff: *value*	Exhalation flow sensor check: *Value* = flow difference between insp (total) flow sensor and exh flow sensor (mL/min). Must be less than 20% difference. |Exp flow - tot flow| < 0.20 * tot flow.	Refer to Section 7.1.6.
Flow Too High: *value*	During FCV calibration, the FCV is leaking more than 1150 mL/min. *Value* = leak in SmL/min.	1. Run approximately160 L/min flow through the FCV to dislodge any debris that might be present on the valve seat/seal. 2. Recal/Replace FCV.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Flow Valve DAC Too Low	FCV- DAC counts went too low without a corresponding decrease in flow.	1. Check flow sensor. 2. Check for sticking valve.
Flow/O2 Disagree: *value1/value2*	During checkout, the O_2 sensor check failed. O_2 and Air flow set to 15 L/min. The O_2% is calculated from the O_2 and Air flow sensors and compared to the measured O_2% from the paracube O_2 sensor. If the absolute difference between the O_2 sensor and the calculated O_2% from flow measurement is > 5% O_2, then the check fails. *value1* = %O_2 measured from flow sensors *value2* = %O_2 measured from paracube	1. Using the Service App, create a flow of approximately 15 L/min on the air channel. 2. Verify (Tot Flow - Air Flow) < (0.15 * Air Flow). 3. If not, replace air pressure regulator. 4. Using the Service App, create a flow of approximately 15 L/min on the O_2 channel. 5. Verify (Tot Flow - O_2 Flow) < (0.15 * O_2 Flow). 6. If not, replace O_2 pressure regulator. 7. Recalibrate O_2 sensor. 8. Repeat tests 2 and 5. If only one fails, replace that channel's flow sensor. If both fail, replace total flow sensor. 9. Replace O_2 sensor.
High Pressure Air Leak Test	Vent engine high air pressure leak test in progress.	None
High Pressure O2 Leak Test	Vent engine high O_2 pressure leak test in progress.	None
Insp Span Counts: *value*	Inspiratory pressure sensor DAC counts that correspond to 100 cmH_2O. (range: 3026 to 3589)	None
Leak Check Passed	Breathing circuit leak check passed with leak less than 1 L/min (@ 25 cmH_2O).	None
Low Air Pressure: *value*	Air supply pressure < 30 psig	Verify proper gas supply.
Low Exp Pressure: *value*	During exh valve cal, the pressure dropped more than 1.25 cmH2O in 4 msec. *Value* = Paw at last good calibration point.	Check for disconnected breathing circuit during calibration.
Low Max Flow: *value*	FCV - Indicator that system will use the degraded wall supply routine for FCV calibration.	Check gas supply source to see if it is too weak or restricted if this causes problems.
Low O2 Pressure: *value*	O2 supply pressure < 30 psig	Verify proper gas supply.
Low Pressure Leak Chk	Breathing circuit leak check in progress.	None
Low Pressure Leak Test	Vent engine low pressure leak test in progress.	None
Measure Resis Chk	Breathing circuit resistance measurement in progress.	None
Measuring P0.1	P0.1 procedure in progress	None

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
No Supply Pressure	Supply pressure for both Air and O_2 is below 30 psi.	Verify proper gas supply.
None	No calibrations, zero measurements, or checkout tests are running	None
O2 Flush Time: *value*	*Value* = time (sec) needed to flush system with O_2 until stability of 0.1% O_2 is reached.	None
O2 Sensor Fail	Failed Paracube communications during O_2 sensor check	Replace Paracube.
O2 Sensor: Failed 100% Cal	Paracube Cal never competed, timed out during 100% O_2 cal	Check paracube sensor.
O2 Sensor: Failed 21% Cal	Paracube Cal never competed, timed out during 21% O_2 cal	Check paracube sensor.
O2 Too Low for 100% Cal	Measured O_2% < 41% during the 100% span calibration of the O2 sensor.	1. Verify proper connection of gases to ventilator. 2. Use the Service App's ***O2 Sensor*** cal to override limits on O_2 sensor calibration. 3. Replace Paracube.
O2 Too Low for 21% Cal	Measured O_2% < 8% during 21% calibration of O2 sensor.	1. Verify proper connection of gases to ventilator. 2. Use the Service App's ***O2 Sensor*** cal to override limits on O_2 sensor calibration. 3. Replace Paracube.
O2 Valve Cal OK	O_2 Valve Cal Passed.	None
Oxygen Flow Sensor Chk	Oxygen Flow Sensor Check.	None
Oxygen Sensor Check Passed	O_2 flow sensor check passed.	None
Paracube	O_2 Sensor calibration in progress.	None
Paracube Check Passed	O_2 sensor check passed.	None
Paracube Chk	Paracube (O_2 sensor) check in progress.	None
Paw Xducer Check	Airway pressure sensor check in progress.	None
Paw Xducer OK	Airway pressure sensor check passed.	None
Regulator Step	Regulator oscillation test in progress.	None
Regulator Step Done	Regulator oscillation test completed.	None

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Relief Pressure: *value*	Safety Valve check: *Value* = back pressure generated from 75 L/min flow thru open relief valve. Must be less than 10 cmH_2O to pass.	Refer to Section 7.1.4.
Relief Time: *value*	Safety Valve check: *Value* = time required to relieve pressure in system from 34 to less than 2 cmH_2O. Must be less than 250 msec to pass.	Refer to Section 7.1.4.
Relief Valve Chk	Relief valve check in progress.	None
Resistance Check Passed	Resistance Check Passed.	None
Safety Valve Check Passed	Safety Valve Check Passed.	None
Sensor Disagree: *value*	During FCV calibration, if the Air (or O_2) flow sensor disagree by more than: 20% of total flow or 1500 mL/min, whichever is greater, the calibration will fail. *Value* = flow difference between Air (or O_2) flow sensor and total flow sensor.	1. Check regulator for oscillation. 2. If only one FCV cal fails, replace that flow sensor. 3. If both FCV cal fail, replace total flow sensor.
Sensor Removed	Exhalation flow sensor removed prior or during checkout.	Install exh flow sensor and rerun checkout.
Span	Pressure transducer span calibration is in progress.	None
Tot: *value1* 02: *value2*	During O_2 flow sensor check, O_2 flow sensor is more than 15% different than total flow sensor at a nominal flow of 30 L/min. *Value1* = measured total flow. *Value2* = measured O_2 flow.	1. Check regulator for oscillation. Replace if necessary. 2. If only O_2 flow sensor check fails, replace O_2 flow sensor. If both Air and O_2 flow sensor checks fail, replace total flow sensor.
Waiting for supply pressure	FCV calibration - if a weak supply pressure is used, system will occasionally pause and wait for supply pressure to come back up before resuming FCV cal.	None; normal operation.
Weak Supply Detected1: *value*	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply pressure was detected when trying to ramp the flow up to 165 L/min.
Weak Supply Detected2: *value*	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply pressure was detected during the 120 L/min flow test.
Weak Supply Detected3: *value*	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply was detected during final flow ramp-up before first cal points are taken.

Message in "*Calibration running*" field	**Reason**	**Troubleshooting**
Weak Supply Detected4: *value*	FCV calibration - Indicator that system will use the degraded wall supply routine for FCV calibration.	None; normal operation. A weak supply was detected during final flow ramp-up before first cal points are taken if DAC output reached 65,000 counts before flow reached 170 L/min.
Xducer Error: *value*	During Paw Xducer check, the insp and exp pressure difference > 4 cmH_2O. *Value* = pressure difference.	Refer to Section 7.1.1.
Zero flow samp	Error in FCV calibration cal point projection.	Check for weak or restricted gas pressure supply
Zero for flow sampl2	Error in FCV calibration cal point projection.	Check for weak or restricted gas pressure supply
Zero Pressure Sensors	Airway pressure sensors are currently being zeroed.	None

Notes

8 Service Diagnostics and Software Download

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8.1 EV Service Application

This section documents the EV Service Application that loads from a PCMCIA card and is used to download software or to run various diagnostic functions.

To run the application, first set the system power switch to Off. Insert the card carrier (with card facing to the rear) into the rear PCMCIA interface slot of the display unit (behind left side door), then set the system power switch On. The service application will load and display the Main Menu along with the System Information page.

8.1.1 Main Menu and System Information

The Main Menu appears on the left-hand side of the screen and includes the following selections:

Main Menu	Remarks
Power Diagnostics	Access to the Power Supply Diagnostics functions
Display Diagnostics	Access to the Front Panel Controls
Special Functions	Access to logs and compatibility tables

Software Download	Access to the Software Download function.

Note You can not return to the Diagnostic section of the service application after entering the software download section. You must reboot the system to exit Software Download.

The System Information page appears on the right-hand side of the screen and displays the following system information:

System Information

Subsystem	HW Rev	Serial #	SW Ver #	Boot
Front Panel Cntl	- - -	- - -	XX.XX	XX.XX
Power Monitor Bd	XXXX/A/XX	ABCXXXXX	XX.XX	XX.XX
Vent Monitor Bd	XXXX/A/XX	ABCXXXXX	XX.XX	XX.XX
Vent Control Bd	XXXX/A/XX	ABCXXXXX	XX.XX	XX.XX
Dsply Unit BIOS	XXXX/A/XX	ABCXXXXX	XX.XX	
Dsply Unit App	XXX/A/XX	ABCXXXXX	XX.XX	

Machine Serial Number: ABCDXXXXX

PC Card ID: XXXXXX

8.1.2 Power Diagnostics

The service application provides power supply diagnostics for the various circuit boards in the EV ventilator.

Selecting ***Power Diagnostics*** on the Main Menu brings up the following menu selections in the left-hand frame and the instructions in the right-hand frame:

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Power Diagnostics	**Power Diagnostics Instructions**
Power Control Display Unit -> Main Menu	Select a menu item to see the power status and measured voltages. To troubleshoot a power problem, start with the power controller and work forward. Problem voltages are in red.

8.1.3 Power Controller Power Diagnostics

There are two pages of diagnostics for the Power Controller.

Selecting ***Power Control*** brings up the first page of the Power Controller Diagnostics.

Power Diagnostics
Power Control
Display Unit
->Main Menu

(Page 1 of 2)
Power Control Power Diagnostics

Label	Value Format	Units	Normal range
AC Status	OK, Fail		
12Vdc Supply	XX.XX	Vdc	11.70 to 12.30
3.3Vdc Supply	X.XXX	Vdc	3.201 to 3.399
1.5 Vdc Supply	X.XXX	Vdc	1.45 to 1.55
Battery Connected	Yes, No		
Battery Status	Fail, Bulk Chg, Over Chg, Float Chg, Trickle Chg, Discharge		
Battery Current	X.XXX	A	
Calc Battery Time	XX	Min	0 to 30
Battery 1 Volts	XX.X < 6.0 FAIL (red) <10 T Chg (yellow) 10-15.5 (Green)	Vdc	10.0 to 15.5
Battery 2 Volts	XX.X < 6.0 FAIL (red) <10 T Chg (yellow) 10-15.5 (Green)	Vdc	10.0 to 15.5
Date Battery Tested	XX-ABC-XXXX		
Last Full Discharge Time	XXX	Min	
Ext'l Battery Current	X.XX	A	

Turn the ComWheel to select the second page.

Push the ComWheel to return focus to the Power Diagnostics selection menu.

Power Diagnostics
Power Control
Display Unit
->Main Menu

(Page 2 of 2)
Power Control Power Diagnostics

Label	Value Format	Units	Normal range
Board Temperature	<65C OK (green) >65C <75C Warn (Yellow) >75C Fail (red)	Deg C	Upper Limit 64
Fan Speed	Slow, Fast		
Fan 1 Voltage	XX.XX (high fan speed = 23.7V typical) (low fan speed = 20.7V typical)	Vdc	17.5 to 25.0
Fan 1 Status	Fail, OK		
Fan 2 Status	Fail, OK		

Turn the ComWheel to return to the first page.

Push the ComWheel to return focus to the Power Diagnostics selection menu.

8.1.4 Display Unit Power Diagnostics

Selecting ***Display Unit*** brings up the Display Unit Power Diagnostics page.

Power Diagnostics
Power Control
Display Unit
->Main Menu

Display Unit Power Diagnostics

Label	Value Format	Units	Normal range
5.0Vdc (PCMCIA)	X.XX	Vdc	4.50 to 5.50
3.3Vdc (PCMCIA)	X.XX	Vdc	2.97 to 3.63
5.0Vdc (Fan)	X.XX	Vdc	4.50 to 5.50
5.0Vdc (USB)	X.XX	Vdc	4.50 to 5.50
8.0Vdc (DIS)	X.XX	Vdc	7.20 to 8.80
11Vdc (LCD)	XX.XX	Vdc	10.35 to 13.62

8.2 Display Diagnostics

The service application provides several pages for display diagnostics.

Selecting ***Display Diagnostics*** on the Main Menu brings up the following menu selections in the left-hand frame:

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Display Diagnostics	**Display Diagnostics Instructions**
Test LEDs Test Speaker Test Backlight 1 Test Backlight 2 Test Keys -> Main Menu	Select a menu item To troubleshoot a display problem, start with Test LEDs and work forward

Display Diagnostics	**Action when selected**
Test LEDs	Selecting ***Test LEDs*** causes the red and yellow LEDS next to the **Silence Alarms** key to flash for 10 seconds.
Test Speaker	Selecting ***Test Speaker*** causes the speaker to sound for 5 seconds.
Test Backlight 1	Selecting ***Test Backlight 1*** turns backlight 2 off for 10 seconds. “If screen goes black during test, a backlight is out”
Test Backlight 2	Selecting ***Test Backlight 2*** turns backlight 1 off for 10 seconds. “If screen goes black during test, a backlight is out”
Test Keys	Selecting ***Test Keys*** brings up a representative display of the front panel controls. Pressing a softkey will cause the corresponding key text to be highlighted.
Main Menu	Selecting ***Main Menu*** returns to the Main Menu.

8.3 Special Functions

Selecting ***Special Functions*** on the Main Menu brings up the following menu selections in the left-hand frame:

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Special Functions	System Information
View Error Log	
View Alarm Log	
View Event Log	
View Revision Log	
Compatibility Table	
PC Card Install Log	
View Install Errors	
-> Main Menu	

Subsystem	HW Rev	Serial #	SW Ver #	Boot
Front Panel Cntl	---	---	XX.XX	XX.XX
Power Monitor Bd	XXXX/A/XX	ABC00000	XX.XX	XX.XX
Vent Monitor Bd	XXXX/A/XX	ABC00000	XX.XX	XX.XX
Vent Control Bd	XXXX/A/XX	ABC00000	XX.XX	XX.XX
Dsply Unit BIOS	XXXX/A/XX	ABC00000	XX.XX	
Dsply Unit App	XXX/A/XX	ABC00000	XX.XX	

Machine Serial Number: ABCD00000

PC Card ID: XXXXXX

Error, Alarm, Event Logs

In a functioning system, the Error, Alarm, and Event Logs are accessible on the system's Service Log menu (refer to *Section 4.4.3*). If a system comes up in a "Failed State", you can download the logs to the Service Application PC Card and view them on the Special Functions screen.

1. With the system still in the "Failed State", insert the Service Application PC Card into the Display Unit and press the "Help" softkey.
2. Wait approximately 60 seconds while the logs are downloaded to the card (no apparent activity).
3. Restart the system with the Service Application to view the logs.

Revision and PC Card Install Logs

Whenever a Software Download is completed, the specific software download is recorded in the Revision Log that resides on the system (Display Unit) and in the PC Card Install Log that resides on the PC Card.

Compatibility Table

The Compatibility Table lists the current software components that last downloaded on to the system. In essence, it is the latest listing that appears in the Revision Log, which allows you to view the current log directly without having to scroll to it.

8.3.1 View Revision Log

Selecting ***View Revisions Log*** brings up the Revision Log for the system. The log includes chronological entries for every Software Download that was completed to the system. Each entry includes two header lines and eight data lines in the following format:

View Revision Log

```
# Software configuration after download on (day) (date) (time)
# SvcApp Ver (XX.XX), Machine Serial Number (ABCDXXXXX) Card # XXXXXXX/
System Version XX.XX
EV FPC,                          *,  (Software Level),  (File Name)  (#---------)  Front Panel Cn
EV PMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Power Monitor
EV VCB,                          *,  (Software Level),  (File Name)  (#XXXXXX) Vent Control B
EV VMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Vent Monitor B
EV DUA,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit App
EV DUB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit BIO
EV DUF,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit Fon
```

Note The Stock Number listed is for the board assembly and may not represent an orderable service item. Refer to the parts lists in Section 10 for service level stock numbers.

The Front Panel Control (FPC), Display Unit Application (DUA), and the Display Unit Flash (DUF) reside, along with the Display Unit BIOS (DUB), on the Display Unit CPU board.

8.3.2 View PC Card Install Log

Selecting ***View PC Card Install Log*** brings up the PC Card Install Log for the software download card. The log includes chronological entries for every Software Download that was completed with the card. Each entry includes two header lines and eight data lines in the following format:

PC Card Install Log

```
INSTALLATION LOG for PC Card # XXXXXXX

# Software configuration after download on (day) (date) (time)
# SvcApp Ver (XX.XX), Machine Serial Number (ABCDXXXXX), Card # XXXXXXX/
System Version XX.XX
EV FPC,                          *,  (Software Level),  (File Name)  (#---------)  Front Panel Cn
EV PMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Power Monitor
EV VCB,                          *,  (Software Level),  (File Name)  (#XXXXXX) Vent Control B
EV VMB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Vent Monitor B
EV DUA,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit App
EV DUB,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit BIO
EV DUF,   (Stock Number)  (RevX),  (Software Level),  (File Name)  (Serial #)  Dsply Unit Fon
```

8.4 Software Download

Main Menu
Power Diagnostics
Display Diagnostics
Special Functions

Software Download

Selecting ***Software Download*** bring up the following information page:

ENTERING SOFTWARE DOWNLOAD MODE!

To return to Diagnostics: turn On/Standby switch to Standby, and turn off AC mains switch in rear. Wait 20 seconds, then turn on power with the AC mains switch and the On/Standby switch.

(Press ComWheel to continue with Download.)

Note You can not return to the Diagnostic section of the service application after entering the software download section. You must reboot the system to exit Software Download.

Entering software download brings up the Software Download menu.

Software Download	Remarks
Download New	Downloads only new software versions not found on the system and compatible with installed subsystem hardware.
Download All	Downloads all software subsystems.

Since downloading all the subsystem software can take an hour or more, you should normally choose “Download New” to install only the updated subsystem software or software required for newly installed subsystems.

Software Download
Download New
Download All

Software Download Status

Subsystem	HW Rev	Current SW Rev	New SW Rev	Status
Front Panel Cntl	- - -	XX.XX	XX.XX	Xxxxxx
Power Monitor Bd	XXXX/A/XX	XX.XX	XX.XX	Xxxxxx
Vent Monitor Bd	XXXX/A/XX	XX.XX	XX.XX	Xxxxxx
Vent Control Bd	XXXX/A/XX	XX.XX	XX.XX	Xxxxxx
Dsply Unit BIOS	XXXX/A/XX	XX.XX	XX.XX	Xxxxxx
Dsply Unit App	XXXX/A/XX	- - -	XX.XX	Xxxxxx
Dsply Unit Fonts	XXXX/A/XX	XX.XX	XX.XX	Xxxxxx

Loading Xxxx Xxxxxxxx Xxxx:
****

Notes about downloading software

If there is no Front Panel Control software installed in the system (as would be the case when the display units control board is replaced), the Service Application automatically downloads the Front Panel Controls software at startup. During the download the two display unit LEDs will flash and the display speaker will sound an alarm tone to indicate that Software Download is proceeding. The display will be black until the automatic download is complete.
To ensure that all software versions on the system are compatible, the end result of "Download All" or "Download New" will be the same. The software loaded on the machine will exactly match what is on the card. Be sure to have the latest/correct version of software before attempting a download to avoid inadvertent overwrites of newer software with an older version.
If, during the "Download New" process, the compatibility checker detects a newer version of software component on the system, a "Notice" appears on the screen that asks you to confirm the downgrade.
"Download All" will download all compatible software from the card to the system without issuing a notice that newer version of software component may be on the system.

Download process

The PCMCIA card includes only the latest software for each subsystem along with the diagnostic application.

As each subsystem software segment is being downloaded, the following status messages note the state of each subsystem and the result of the download:

- ***Busy*** - System is running its application code; not ready for download.
- ***Ready*** - System is in its boot code; ready for download.
- ***CRCtest*** - System is analyzing the download CRC.
- ***Loading*** - System is accepting download data.
- ***Done*** - Software download has completed successfully.
- ***Fail*** - Software download did not complete successfully. A "Fail" message will require reloading of the software; or repair of the system may be necessary.
- ***Skipped*** - Software download was bypassed.
- ***Linked*** - System is communicating, but status is not yet known.
- ***Not Compatible*** - The software version on the PCMCIA card is not compatible with the subsystem.

If the subsystem is communicating but the HW Rev or current SW Rev are not known, the message ***Unknown*** will appear under the columns for those values. If the HW Rev or current SW Rev are not known, the download function will still be available.

As the software loads, an activity bar at the bottom of the screen shows the download progress for each subsystem.

Download complete

When all the required subsystem software is download, the following message appears on the screen. You must shut down the system to exit the download function.

DOWNLOAD IS COMPLETE.

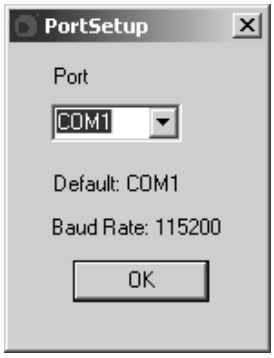
Remove PCMCIA card.
Turn OFF AC mains switch in rear.
Disconnect power cord.

8.5 EV Service Application (PC based)

This section documents the EV Service Application that run on a Windows based computer and communicates with the EV ventilator through the serial port (RS-422 Port 3).

To enable communication between the EV and the PC Service Application, the EV must be in the Service mode.

8.5.1 Port Setup



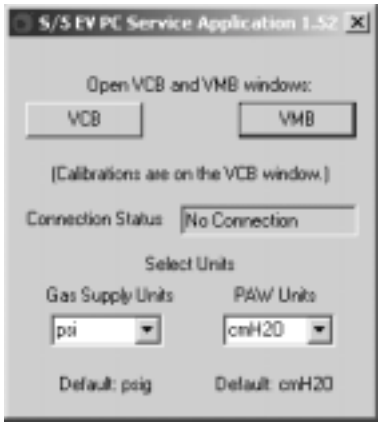
When the EV serial port is enabled, the PC application presents a port setup menu that allows you to select a COM port for your PC. Select the appropriate COM port and click OK to continue.

Note: Ensure that no other application (such as PDA hot-sync) is using this port while the Service Application is running.

Menu Item	Selections	Default
Port	COM1, COM2, COM3, COM4, COM5, COM6, COM7, COM8,	COM1

8.5.2 Main Menu and System Information

The Main Menu appears on the screen and includes the following selections as shown in the table below:



Main Menu	Remarks
VCB	Opens the VCB Diagnostics page.
VMB	Opens the VMB Diagnostics page.

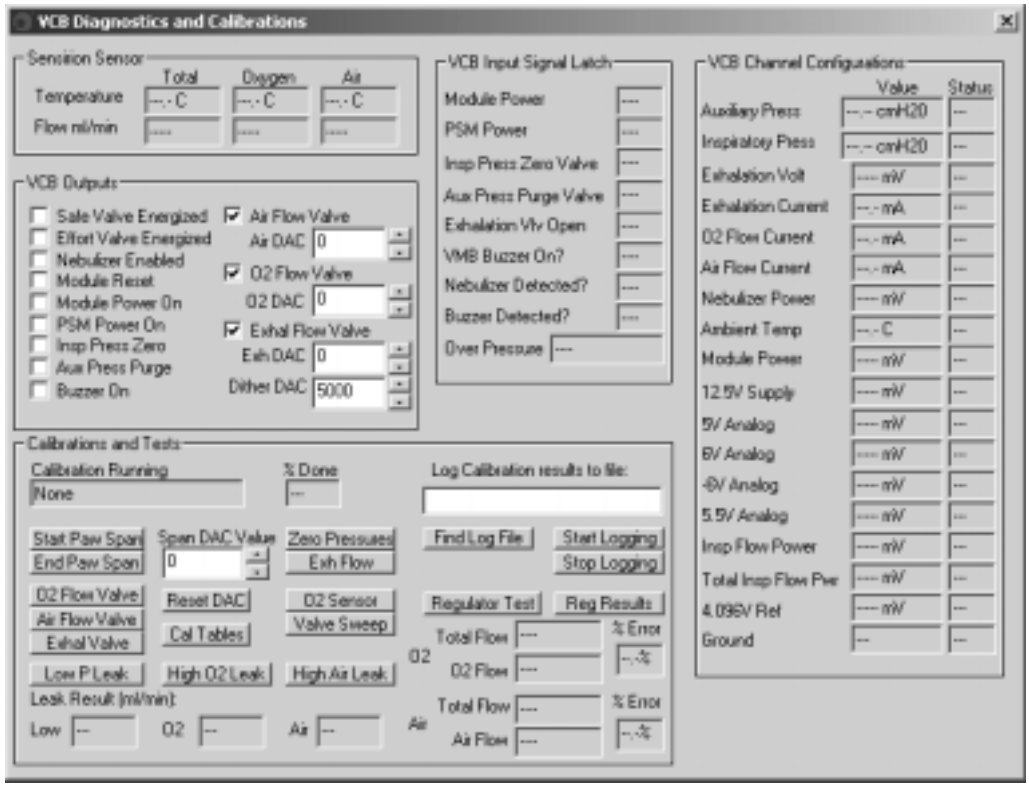
The main menu includes a message area that show whether or not the program is communicating with the EV.

The VCB and VMB Diagnostics pages can both be displayed at the same time.

Closing the main menu, closes the application.

8.6 VCB Diagnostics and Calibration

Selecting ***VCB Diagnostics and Calibration*** on the Main Menu brings up the following page that contains five grouped area.



8.6.1 Sensirion Sensors

The Sensirion (Inspiratory Flow) Sensors group shows the temperature and the flow through each flow sensor: Total flow, Oxygen, and Air.

Item	Total	Oxygen	Air
Temperature	XXX.X C	XXX.X C	XXX.X C
Flow ml/min	XXXXXX	XXXXXX	XXXXXX

8.6.2 VCB Input Signal Latch

The VCB Input Signal Latch group shows the status of the displayed item.

Item	Description
Module Power	FAIL = Power to the monitor module has failed. OK = Module Power has not failed or module power has been manually shut off.
PSM Power	FAIL = Power to the Patient Side Module has failed. OK = PSM Pwr has not failed or PSM power has been manually shut off.
Insp Press Zero Valve	ON = Inspiratory pressure zero valve on. OFF = Inspiratory pressure zero valve off.
Aux Press Purge Valve	ON = Auxiliary pressure purge valve on. OFF = Auxiliary pressure purge valve off.
Exhalation Vlv Open	YES = VMB is commanding the exhalation valve open. NO = The valve is not opened.
VMB Buzzer On?	YES = VMB is activating the buzzer. NO = Buzzer is not active or is activated by the VCB.
Nebulizer Detected?	YES = Nebulizer is connected. NO = Nebulizer is not connected.
Buzzer Detected?	NO = Buzzer current is too low. Valid when buzzer should be on. YES = Buzzer is sensed. NA = Buzzer not being activated.
Over Pressure	DETECTED = Expiratory over-pressure detected. NOT DETECTED = Over pressure was not detected.

8.6.3 VCB Channel Configurations

The VCB Channel Configurations group includes items that are measured from the VCB. If the item is within the acceptable range, “OK” is displayed next to the value. If the item is out of the acceptable range, “FAIL” is displayed instead.

Item	Description	Format	Units	Range
Auxiliary Press	Auxiliary pressure sensor measurement	XXX.XX	cmH2O	-20 to 120
Inspiratory Press	Inspiratory pressure sensor measurement	XXX.XX	cmH2O	-20 to 120
Exhalation Volt	Exhalation valve voltage	XXXXX	mV	0 to 12500
Exhalation Current	Exhalation valve current	XXX.X	mA	0 to 815
O2 Flow Current	O2 Flow Valve drive current	XXX.X	mA	0 to 198
Air Flow Current	Air Flow Valve drive current	XXX.X	mA	0 to 198
Nebulizer Power	Nebulizer power (when on) Nebulizer power (when off)	XXXXX XXX	mV mV	11600 to 12600 0 to 500
Ambient Temp	Ambient temperature near the valve drive circuits	XXX.X	C	0 to 55
Module Power	16 V Circuit breaker for module power	XXXXX	mV	15200 to 16800
12.5V Supply	12.5 V Supply Voltage	XXXXX	mV	12000 to 12700
5V Analog	5V analog supply voltage	XXXXX	mV	4800 to 5200
6V Analog	6V analog supply voltage	XXXXX	mV	5760 to 6240
-6V Analog	-6V analog supply voltage	XXXXX	mV	-6240 to -5660
5.5V Analog	5.5V analog supply voltage	XXXXX	mV	5280 to 5720
Insp Flow Power	9V power supply for the O2 and Air inspiratory flow sensors	XXXXX	mV	8530 to 9240
Total Insp Flow Pwr	9V power supply for the total inspiratory flow sensor	XXXXX	mV	8530 to 9240
4.096V Ref	Analog measurement of the independent 4.096V voltage reference	XXXXX	mV	4055 to 4137
Ground	Measurement of the analog ground at the A to D converter	XXXXX	mV	0 to 10

8.6.4 VCB Outputs

The VCB Outputs group controls items that can be turned on or off. Items whose default state is “On”, initially have a checkmark in the checkbox. For items whose default state is “Off”, the checkbox is initially unmarked.

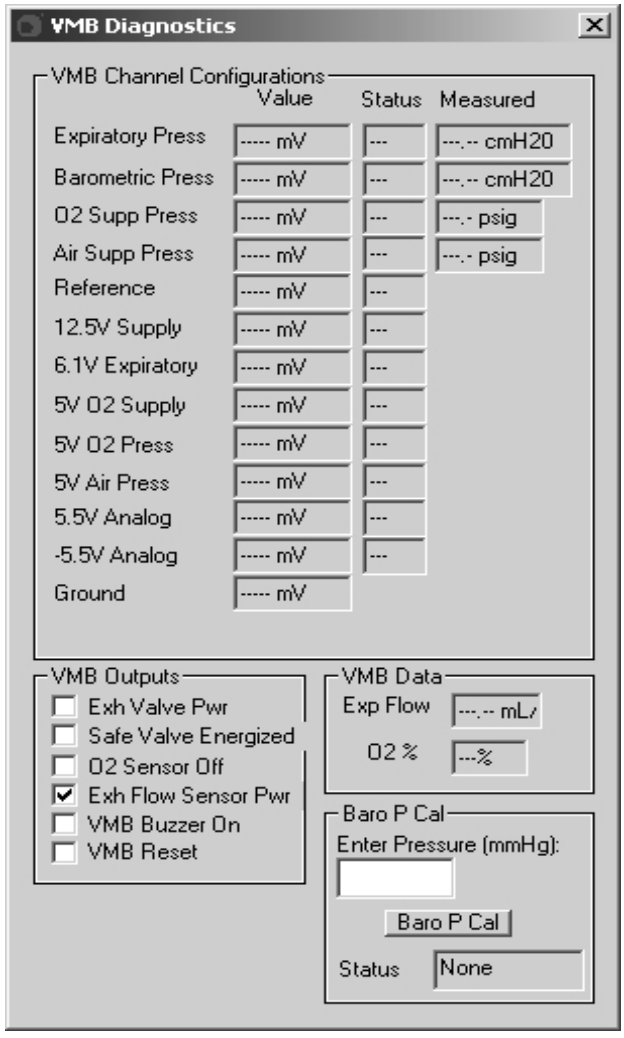
Item	Function	Default
Safe Valve Energized	Opens/Closes Safety Valve.	Not checked
Man Valve Energized	Opens/Closes Inspiratory Maneuver Valve.	Not checked
Nebulizer Enabled	Enables/Disables power to the Nebulizer.	Not checked
Module Reset	Resets modules residing in the module bay.	Not checked
Module Power On	Turns Module Bus power on/off.	Not checked
PSM Power On	Turns Patient Side Monitor power on/off	Not checked
Insp Press Zero	Inspiratory pressure zero valve on/off.	Not checked
Aux Press Purge	Auxiliary pressure purge valve on/off.	Not checked
Buzzer On	Controls the buzzer (On/Off) from the VCB.	Not checked
Air Flow Valve	Enables/Disables Air flow valve. Disabled while a calibration is running.	Checked
Air DAC	Set any DAC value from (decimal) 0 to 65535 for the Air Flow Valve.	0
O2 Flow Valve	Enables/Disables O2 flow valve. Disabled while a calibration is running.	Checked
O2 Dac	Set any DAC value from (decimal) 0 to 65535 for the O2 Flow Valve.	0
Exhal Flow Valve	Enables/Disables Exhalation flow valve. Disabled while a calibration is running.	Checked
Exh Dac	Set any DAC value from (decimal) 0 to 65535 for the Exhalation Flow Valve.	0
Dither Dac	DAC value that adjusts the amplitude of the dither signal to the exhalation valve.	5000

8.6.5 Calibrations and Tests

Item	Description
Calibration Running	Shows the current calibration that is running.
% Done	The percentage of the calibration that is completed.
Start Paw Span	Starts airway pressure transducer zero and span for all three pressure transducers (Insp, Exp, and Aux).
End Paw Span	Ends airway pressure transducer zero and span for all three pressure transducers (Insp, Exp, and Aux).
Span DAC Value	Exhalation valve DAC counts for the Paw Span Test. Default = 0
Reset DAC	Sets DAC value to zero.
O2 Flow Valve	Runs O2 Flow Valve Test.
Air Flow Valve	Runs Air Flow Valve Test.
Exhal Valve	Runs Exhalation Flow Valve Test.
Cal Tables	Displays a new window showing the calibration tables of the Air Flow Valve, O2 Flow Valve, and Exhal Valve tests.
Zero Pressures	Zeros the Inspiratory and Expiratory pressure sensors.
Exh Flow	Exhalation flow sensor zero.
O2 Sensor	Runs the Paracube O2 sensor test.
Valve Sweep	Runs the Valve Sweep calibration.
Low P Leak	Runs Low Pressure Leak Test.
High O2 Leak	Runs High O2 Pressure Leak Test.
High Air Leak	Runs High Air Pressure Leak Test.
Leak Result:	The measured leak from the last Low Pressure, High O2, and High Air leak tests.
Log Calibration results to file:	Enter file name (example D:\testlog1.log).
Find Log File	Searches for a log file that already exists.
Start Logging	Updates selected log as calibrations are completed. Note: The current log overwrites previous entries.
Stop Logging	Turns off the calibration log.
Regulator Test	Runs the Regulator Test.
Reg Results	Opens a window that displays the results of the regulator test.
Total Flow - O2	Displays the Total Flow during the O2 portion of the regulator test.
O2 Flow	Displays the O2 Flow during the O2 portion of the regulator test.
% Error - O2	Displays the error percentage of the Total and O2 Flow during the regulator test.
Total Flow - Air	Displays the Total Flow during the Air portion of the regulator test.
Air Flow	Displays the Air Flow during the Air portion of the regulator test.
% Error - Air	Displays the error percentage of the Total and Air Flow during the regulator test.

8.7 VMB Diagnostics

Selecting ***VMB Diagnostics*** on the Main Menu brings up the following page that contains four grouped area.



8.7.1 VMB Channel Configurations

The VMB Channel Configurations group includes items that are measured from the VMB. If the item is within the acceptable range, “OK” is displayed next to the value. If the item is out of the acceptable range, “FAIL” is displayed instead.

Item	Description	Format	Units	Range
Expiratory Press	Expiratory Pressure sensor measurement	XXX.XX	cmH2O	-26.8 to 131.8
Barometric Press	Barometric pressure sensor measurement	XXX.XX	cmH2O	643.7 to 1182.0
O2 Supp Press	O2 supply pressure sensor measurement	XXX.XX	psig	-9.1 to 127.8
Air Supp Press	Air supply pressure sensor measurement	XXX.X	psig	-9.1 to 127.8
Reference	1.22V Reference	XXXXX	mV	1104 to 1338
12.5V Supply	12.5V Power supply to the VMB	XXXXX	mV	10900 to 13320
6.1V Expiratory	6.1V power supply to the expiratory flow sensor	XXXXX	mV	5770 to 6370
5V O2 Supply	5V power supply to the O2 sensor	XXXXX	mV	4720 to 5380
5V O2 Press	5V power supply to the O2 pressure sensor	XXXXX	mV	4680 to 5340
5V Air Press	5V power supply to the Air pressure sensor	XXXXX	mV	4680 to 5340
5.5V Analog	5.5V analog supply	XXXXX	mV	5140 to 5880
-5.5V Analog	-5.5V analog supply	XXXXX	mV	-6220 to -4440
Ground	Ground	XXXXX	mV	

8.7.2 VMB Outputs

The VMB Outputs group controls items that can be turned on or off. Items whose default state is “On”, initially have a checkmark in the checkbox. For items whose default state is “Off”, the checkbox is initially unmarked.

Item	Function	Default
Exh Valve Pwr	Opens/closes the exhalation valve (opens when checked).	Not checked
Safe Valve Energized	Opens/closes the safety valve from the VMB (energized when checked).	Not checked
O2 Sensor Off	Turn oxygen sensor On (not checked) or Off (checked)	Not checked
Exh Flow Sensor Pwr	Turn exhalation sensor On (checked) or Off (not checked)	Checked
VMB Buzzer On	The VMB turns the buzzer On/Off.	Not checked
VMB Reset	Resets the VMB (disables the watchdog).	Not checked

8.7.3 VMB Data

The VMB Data group shows the reported values for Expiratory Flow and O_2 concentration.

Item	Description	Format	Units
Exp Flow	Expiratory flow sensor measurement.	XXX.XX	mL/min
O2 %	Measured oxygen concentration from the oxygen sensor.	XXX	%

8.7.4 Baro P Cal

Item	Description
Enter Pressure	Enter the local barometric pressure in mmHg. The Baro P Calibration will use this value to calibrate the barometric pressure transducer.
Baro P Cal	Starts the barometric pressure transducer calibration. The calibration will Fail if nothing is entered in the Enter Pressure box.
Status	Displays the results of the barometric calibration (Passed or Failed).

9 Repair Procedures

In this section

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9.2 How to bleed gas pressure from the machine 9-4
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⚠ **WARNING** To prevent fires:

- Use lubricants approved for O_2 environments, such as Krytox. Other lubricants may burn or explode in high O_2 concentrations.
- All covers used on the system must be made from antistatic materials. Static electricity can cause fires in high O_2 concentrations.

⚠ Obey infection control and safety procedures. Used equipment may contain blood and body fluids.

⚠ A movable part or a removable component may present a pinch or a crush hazard. Use care when moving or replacing system parts and components.

⚠ Some internal parts have sharp edges and can cause cuts or abrasions. Use care when servicing internal components.

⚠ When servicing the EV, extreme care must be taken to avoid introducing foreign debris into the pneumatic flow passages of the ventilator. This includes dust and contaminants on the vent engine and particularly metal chips generated by screw threads. Before removing components on the vent engine, secure a clean work area and thoroughly clean the vent engine to remove any contaminants. Failure to do so may result in patient injury and/or damage to the flow valve.

⚠ After repairs are completed, always perform the checkout procedure. Refer to Section 3 of this manual.

⚠ **CAUTION** Electrostatic discharge through circuit boards may damage the components on them. Wear a static control wrist strap before touching the circuit boards. Handle all circuit boards by their non-conductive edges. Use anti-static containers when transporting them.

9.1 Circuit Board Replacement precautions

The EV stores the system serial number and installed optional features (if any) in three locations:

- on the DU CPU board,
- on the VCB,
- and on the PMB.

Each time the system is powered up, the software checks to ensure that the information stored in these locations is the same.

If, on power up, only two of the three boards have matching information (such as would be if one of these boards is replaced), the software loads the information from the two matching boards to the third board. This scheme allows for replacement of these board while retaining machine specific parameters.

Note that no checking or replication occurs when the Service App is loaded. The unit must be powered up with system software.

Caution Do not replace more than one of these boards at a time without first powering up the unit. Wait until the initial checkout menu appears to insure that the machine specific information has been replicated.

9.1.1 Software download

After replacing any of the following boards, download the current software for the newly installed subsystem (refer to Section 8.4):

- Display Unit CPU board (or a replacement DU)
- the Power Monitor board (PMB)
- the Vent Monitor board (VMB)
- the Vent Control board (VCB)

9.1.2 Required calibrations

When repairs are complete, if either the VMB or the VCB were replaced, the following calibrations must be performed before completing the checkout procedure.

If the VMB is replaced,

- calibrate the airway pressure transducers (refer to Section 5.2.7).
- calibrate the barometric pressure transducer (refer to Section 8.7.4).

If the VCB is replaced,

- calibrate the airway pressure transducers (refer to Section 5.2.7).
- calibrate the flow control valves — O2 FCV, Air FCV, and Exhalation Valve (refer to Section 4.3).

9.2 How to bleed gas pressure from the machine

Before disconnecting pneumatic fittings, bleed all gas pressure from the ventilator.

1. Disconnect all gas supplies from the source.
2. Set the system switch to On.
3. Ensure that all pressures read zero.
4. Establish a flow for the affected gas to bleed down the pressure.
5. Set the system switch to Standby.

9.3 Accessing chassis components

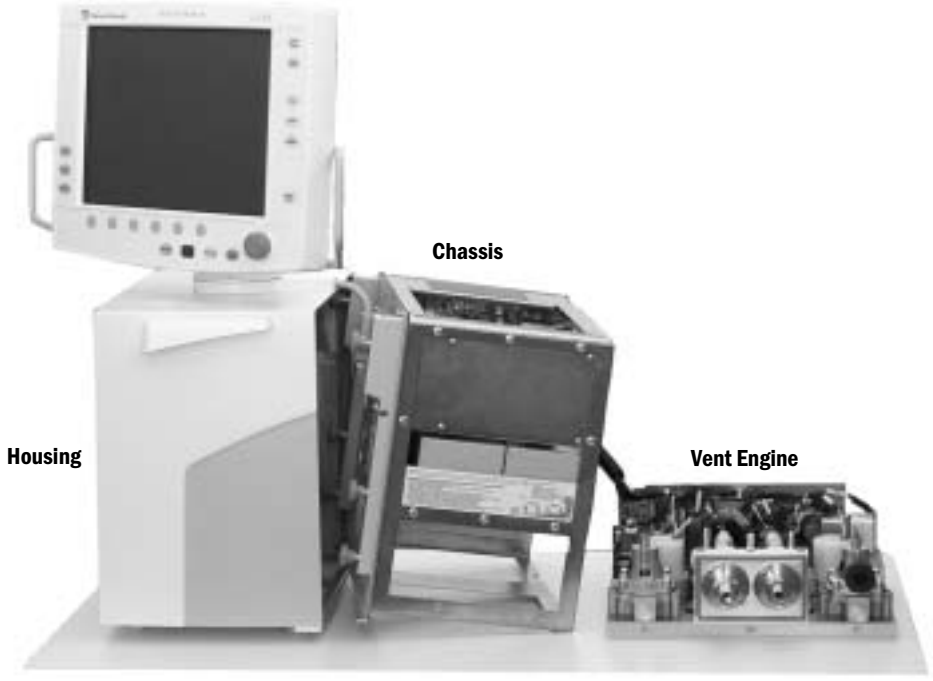
Most of the EV components are mounted to a two-tier chassis that slides out of the housing for access to the internal components.

The pneumatic (and related Vent Engine) components are mounted on a manifold that occupies the lower tier of the chassis. To access the pneumatic components, the entire manifold assembly can be removed from the chassis.

The electrical (and related circuit board) components occupy the upper tier.

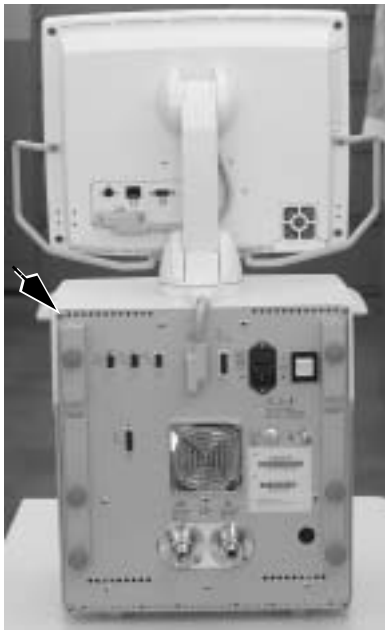
Electrical components on the Vent Engine connect to the Ventilator Control Board (VCB) and the Ventilator Monitor Board (VMB) through a single, two-connector harness.

To diagnose the operation of the EV while still disassembled, the components (Vent Engine, circuit boards, Display Unit) can be arranged and reconnected with existing harnesses. A separate Display Unit Cable can be used as a service tool to make the connection between the Chassis and the Display Unit less restricted.



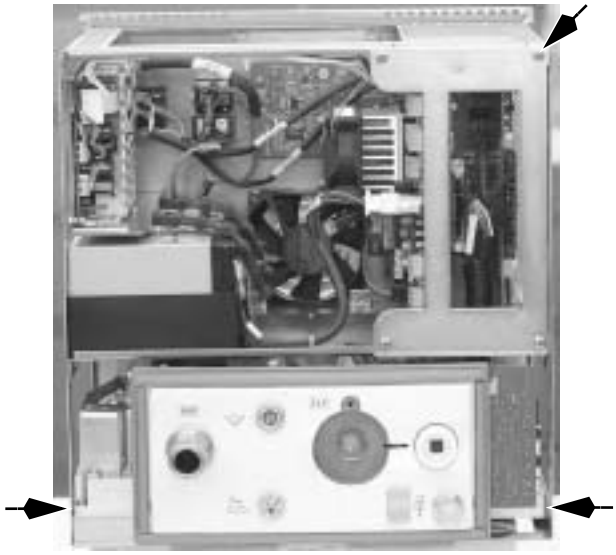
9.3.1 To remove the chassis from the housing

1. To prevent the housing from tipping over when the chassis is removed, position the Display Unit (as shown) centered over the housing.
2. If applicable, remove any patient circuit components.
3. Remove the Exhalation Valve. The chassis can not be removed with the Exhalation Valve in place.
4. Disconnect the Display Cable from the chassis connector.
5. Loosen the four captured mounting screws at each corner of the back panel.
6. Slide the chassis out of the housing.



9.3.2 To remove the Vent Engine from the chassis

1. Remove the circuit board retainer.
2. Disconnect the engine harness connectors from the circuit boards.
3. Remove the four screws (two on each side) that hold the Vent Engine manifold to the chassis.
4. Slide the Vent Engine out of the chassis.



9.3.3 To replace chassis mounted components

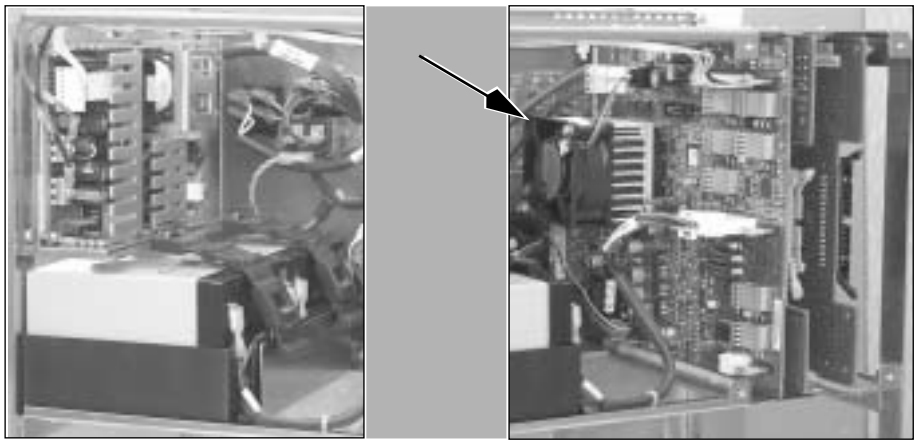
Most of the major components on the chassis can be replaced directly.

Only a few of the less accessible components require you to remove other components before they can be replaced.

When replacing the Power Management Board, transfer the existing heat sink and fan to the new board.

Note: Refer to Section 9.1 for precautions regarding board replacement.

After replacing a circuit board, download current software (refer to Section 9.1.1) and calibrate the system (refer to Section 9.1.2).

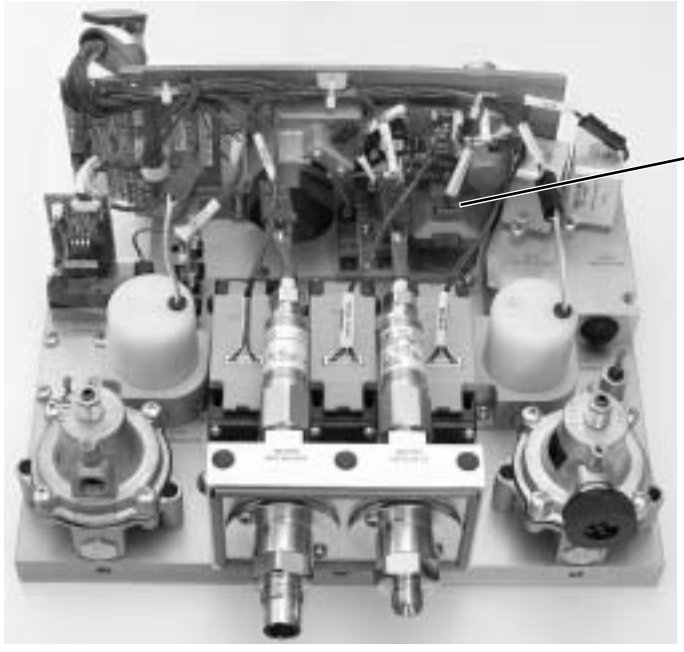


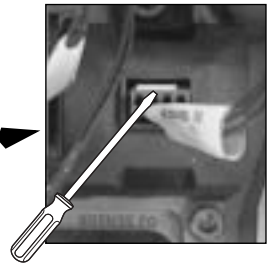
9.3.4 To replace Vent Engine components

All mounting hardware for Vent Engine components can be accessed from the top.

When replacing a component, ensure that the o-ring or gasket under the component is properly seated in the manifold.

To remove the harness connector from the O_2 Sensor, release the retaining tab with a small, thin-blade screwdriver (twist the screwdriver slightly to release the tab).





Note: When replacing the following items, do not overtighten the mounting hardware. Use the following torque spec chart to properly mount the component.

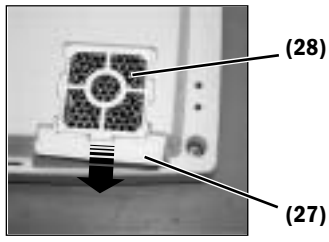
- Regulator = 2 Nm
- Flow Control Valve = 4 Nm
- O_2 Sensor = 2 Nm
- Flow Transducer = 2 Nm
- Inspiratory Valve Assembly Manifold = 4 Nm

9.4 Servicing the Display Unit

Note The item numbers appearing in parenthesis in this section refer to items in the parts list in Section 10.6.

The fan filter **(28)** and the access door **(29)** to the PCMCIA interface can be replaced with the Display Unit in place.

To replace the filter, slide the filter capsule **(27)** downward to remove it from the Display Unit.

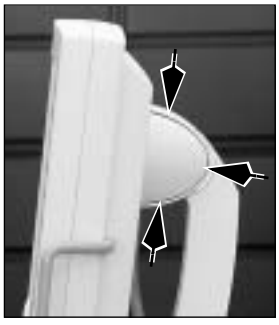


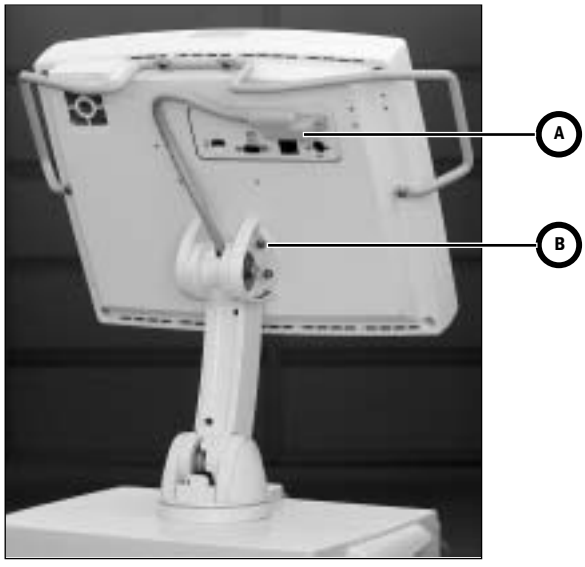
To service other components of the Display Unit, you must first remove the Display Unit from the machine.

9.4.1 Remove the Display Unit

The Display Unit attaches to the pivot arm with screws that are accessible under the pivot covers.

1. Remove the pivot arm covers on each side of the upper pivot.
   - The pivot covers are held in place by three tabs in the locations shown by the arrows.
   - Slide a thin blade between the cover and the pivot housing to release each tab.
2. Raise the DU so that it faces backwards.
3. Disconnect the display cable **(A)**.
4. Remove the four screws that hold the DU to the upper pivot **(B)**.

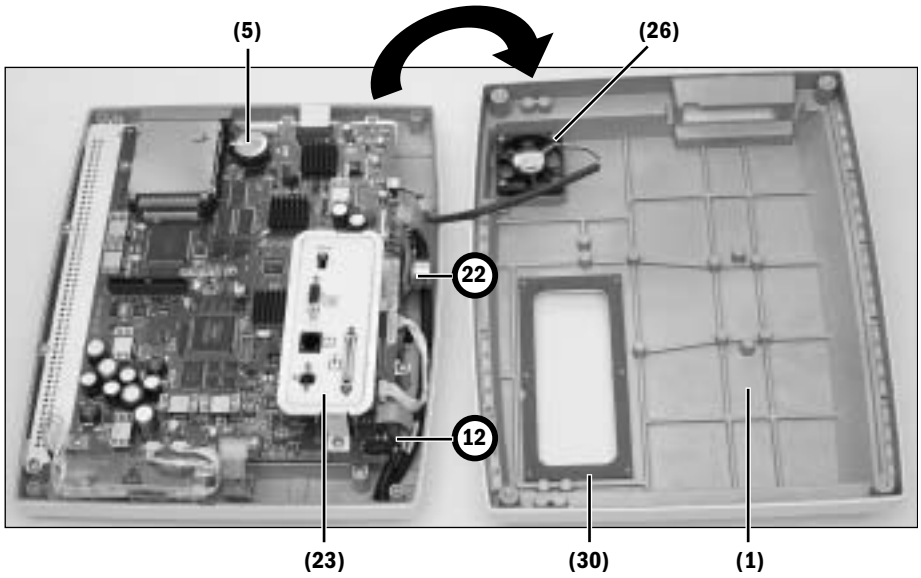




9.4.2 Disassemble the Display Unit

Place the Display Unit face down on an anti-static pad. Before removing the rear enclosure, ensure that the release tabs on the PCMCIA frame are fully depressed.

1. Loosen **(L)** the four captive screws at each corner of the rear enclosure.
2. Lift the rear enclosure slightly and pivot it away from the lower enclosure at the bottom side of the Display Unit.



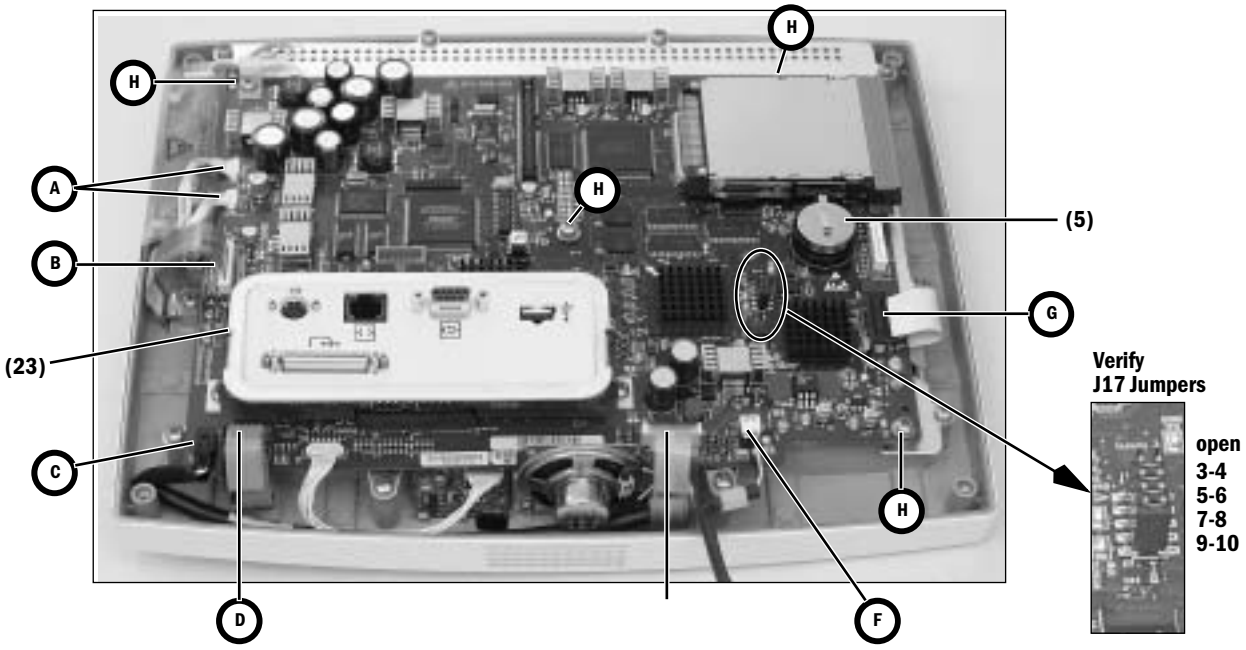
At this point, you can replace the following items (The item numbers refer to the parts list in Section 10.6):

- the **fan (26)**
- the **connector panel assembly (23)**
- the **encoder assembly (12)** E
- the **battery (5)**
- the **speaker (22)** — To access the mounting screws for the speaker, you must first remove the ten screws that hold the mounting plate to the front enclosure so that you can raise the bottom edge of the assembly slightly — Refer to section 9.4.4.)
- the **rear enclosure (1)** — You can transfer the captive screws to the new enclosure. However, the **gasket (30)** is held in place with adhesive. When replacing the rear enclosure, also include a new gasket.

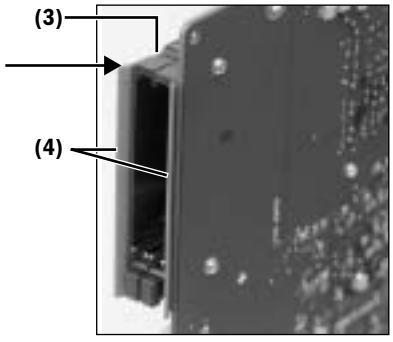
To replace the remaining items requires further disassembly.

9.4.3 To replace the CPU board

1. Remove the **connector panel assembly (23)** — two screws.
2. Disconnect the following cables:
   - Inverter harnesses **(A)**
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(B)**
   - Speaker cable **(C)**
   - Encoder assembly cable **(D)**
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(E)**
   - Fan cable **(F)**
   - LCD cable **(G)**



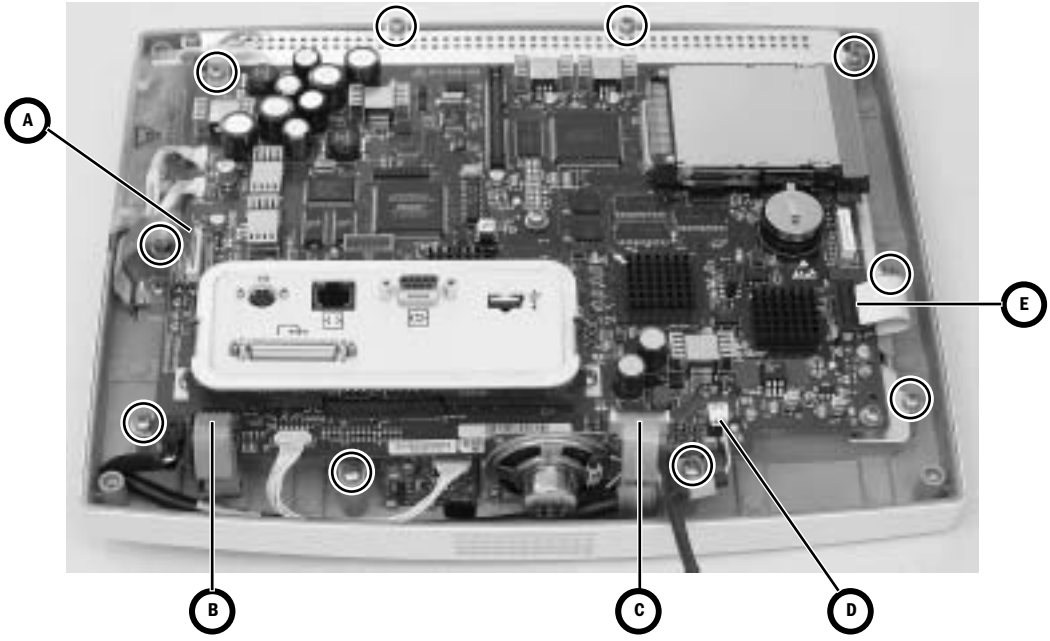
3. Remove the remaining four screws **(H)** that hold the CPU board to the mounting plate.
4. Remove the CPU board from the mounting plate.
5. If you are **replacing the PCMCIA frame (3)** on an existing CPU board (remove four screws on back of CPU board), you must also apply new gaskets **(4)** to the frame. Align the ends of the gaskets with the top edge of the frame.



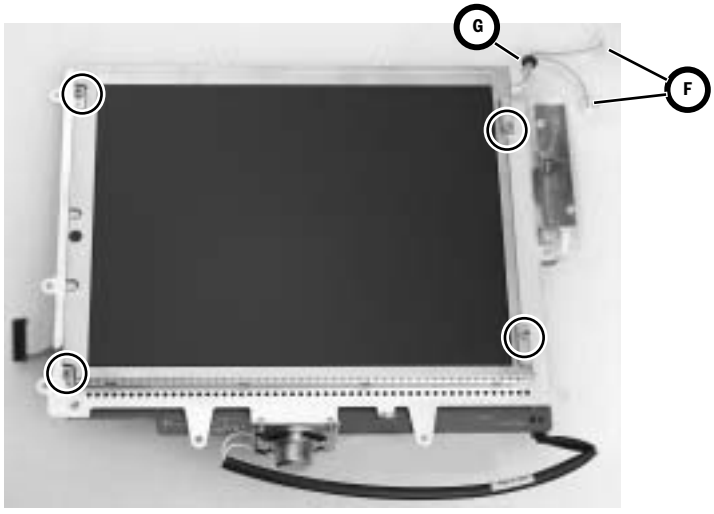
6. Transfer the battery **(5)** to the new CPU board.
7. Reassemble in reverse order.
8. Download latest software (Section 8.4).

9.4.4 To replace the LCD display

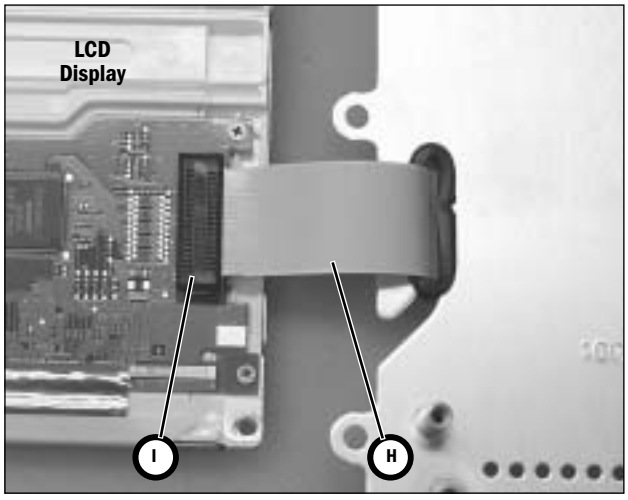
1. Disconnect the following cables:
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(A)**
   - Encoder assembly cable **(B)**
   - Membrane switch flex-cable at ZIF (zero insertion force) connector **(C)**
   - Fan cable **(D)**
   - LCD cable **(E)**
2. Remove the ten screws (**circled**) that hold the mounting plate to the front enclosure.



3. Remove the mounting plate assembly from the front enclosure.
4. Disconnect the backlight harnesses **(F)** from the inverter boards.
5. Slide the grommet **(G)** out of the mounting plate slot (transfer to new LCD).
6. Remove the four screws (**circled**) that hold the LCD to the mounting plate.



7. Lift the left side of the LCD display slightly away from the mounting plate to pull some of the display ribbon cable **(H)** to the top side of the plate. Flip the LCD over to the left of the assembly.
8. Disconnect the display ribbon cable **(I)**.



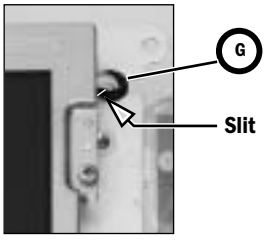
9. Reassemble in reverse order.

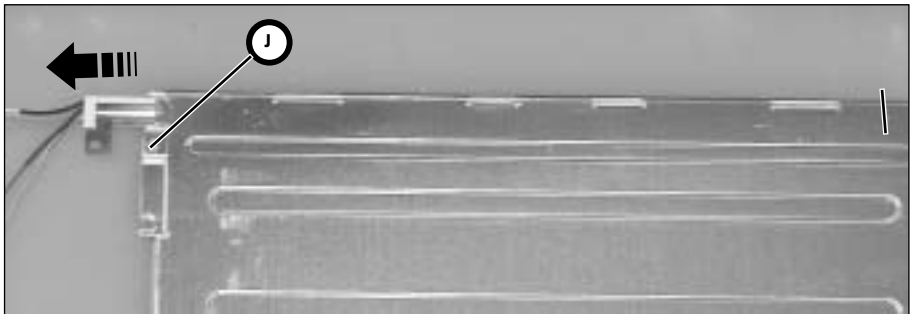
   Note: When replacing the LCD, pull the excess ribbon cable to the bottom side of the plate as you lower the LCD on to the plate. For the backlight harness grommet **(G)**, ensure that the slit in the grommet faces toward the inside of the keyhole.

9.4.5 To replace the backlights

The backlight replacement kit includes a backlight assembly (with two backlights) and two inverters with mounting hardware. To replace the backlight assembly follow the procedure in Section 9.4.4 to gain access to the assembly. To replace the inverters, follow the procedure in the next section.

1. Remove the one screw **(J)** that holds the backlight assembly to the LCD.
2. Slide the backlight assembly to the left to free it from the retaining tabs and then lift it out of the holder.





3. Transfer the grommet **(G)** to the new backlight assembly.
4. Reassemble in reverse order.

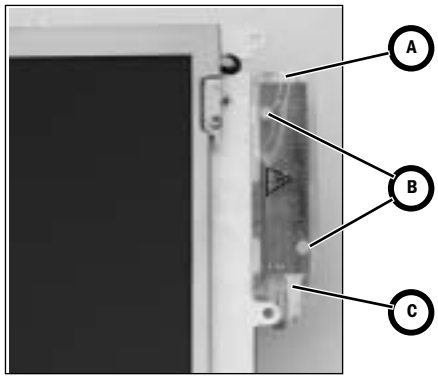
9.4.6 To replace the Inverters

The Display Unit includes two inverters (one for each backlight).

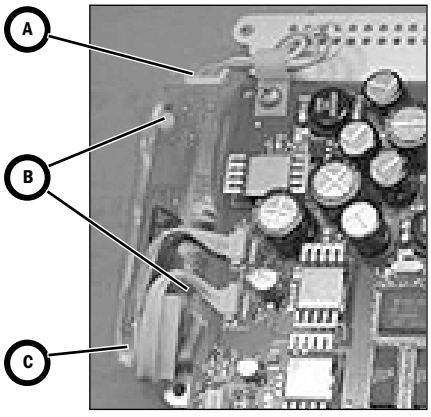
The inverters “sandwich” the mounting plate and use it as a heatsink. Follow the procedure in Section 9.4.4 to gain access to the inverters. Replace one inverter at a time.

1. Disconnect the backlight cable **(A)** from the inverter.
2. Remove the two Nylon screws **(B)** that hold the inverter to the backplate.
3. Slide the inverter out of the sleeve and disconnect it from the CPU harness **(C)**.
4. Reassemble in reverse order.

The “front” inverter



The “rear” inverter



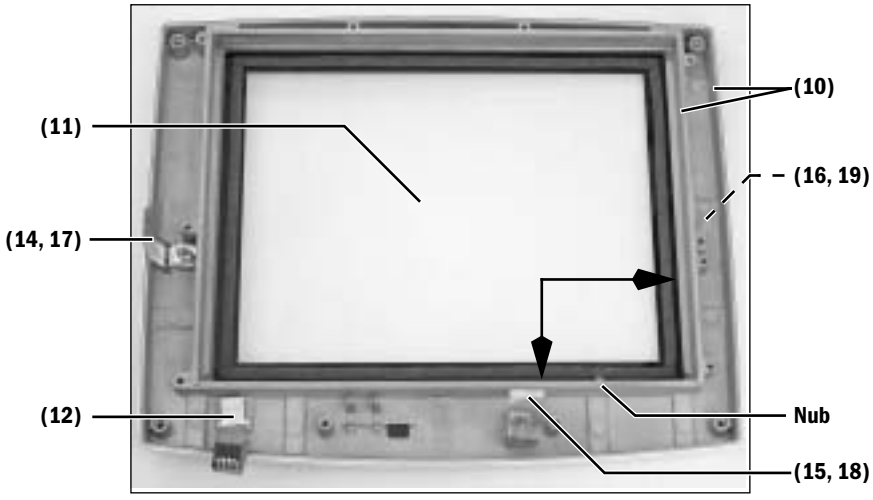
9.4.7 To replace the front enclosure or components

Disassemble the Display Unit following procedures in the previous sections to the point where you have removed the mounting plate assembly from the front enclosure.

If you are replacing the front enclosure, you can transfer the encoder **(12)** assembly to the new enclosure; but, you must build up the replacement enclosure with:

- a new window **(11)**
- new membrane switches — right-side **(14)**, lower **(15)**, left-side **(16)**
- new keypads - right-side **(17)**, lower **(18)**, left-side **(19)**
- new EMC gasket **(10)**

If you are replacing a keypad or a membrane switch, you must replace both items.

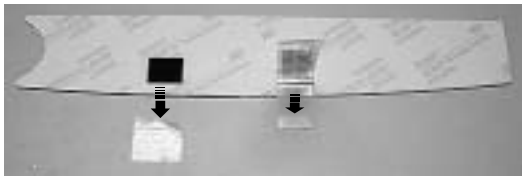


To replace the window

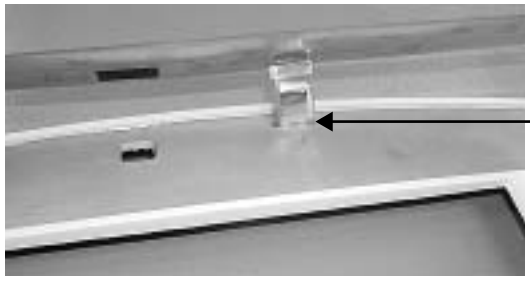
1. Place the front enclosure face up on a flat surface.
2. Press down on one corner of the window to free it from the enclosure.
3. Work your way around the window until you can get a hold of it from the back.
4. Slowly pry the window from the enclosure.
5. Place the front enclosure face down on a flat surface, taking care not to damage the encoder.
6. Remove any remaining residue from the mounting area; clean with isopropyl alcohol.
7. Remove the inside protective material from the front of the window.
8. Peel the front outside frame of the release liner.
9. Lower the window straight down in the enclose, noting the notch in the window and the matching nub on the enclosure.
10. Before seating the window, position it in contact with the bottom and right sides of the frame (see arrows) so that the larger gap between the window and the enclosure is at the top and left edges (as viewed from behind).
11. Remove the protective film from the back side of the window.

To replace a membrane switch and keypad

1. Remove the screw that attaches the grounding strap to the enclosure.
2. Pry the membrane switch and keypad from the enclosure.
3. Remove any remaining residue from the mounting area; clean with isopropyl alcohol.
4. Remove the backing from the membrane. Be sure to remove the small backing below the flex cable. For the lower membrane, remove the protective film from the IRDA window.



5. Insert the flex cable and ground strap through the slot in the enclosure. Ensure that all of the ground strap passes through the slot an does not remain folded over under the membrane.



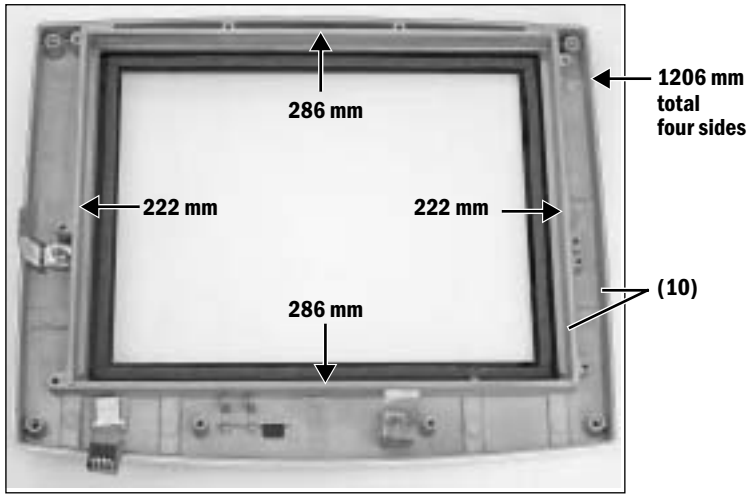
6. Carefully lower the membrane straight down to the enclosure. Seat the membrane in place.
7. Remove the backing from the keypad and install it over the membrane switches.
8. Attach the ground strap to the enclosure.

To install the EMI gasket

To fully seal the Display Unit enclosure, you will need approximately 2.3 meters of EMC gasket **(10)**. Cut the gasket into five strips shown below.

Insert a continuous length of gasket in the outside grove of the enclosure (sparingly apply "Super Glue Gel" to the channels near the corners before installing the gasket).

Insert individual lengths of gasket in the inside grove around the window (sparingly apply "Super Glue Gel" to the channels near the corners before installing the gasket).



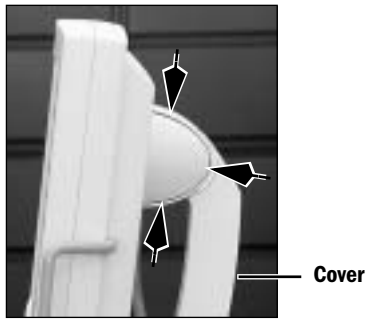
9.5 Adjusting the display arm

The display arm includes three pivot points that allow the Display Unit to be positioned for optimal viewing:

- the upper pivot allows for tilting the display
- the lower pivot allows for raising or lowering the display
- the arm mounts to the chassis on a bearing that allows the display to be moved side to side.

To access the adjustment hardware for the upper and lower hardware, remove the pivot arm covers on each side of the pivot.

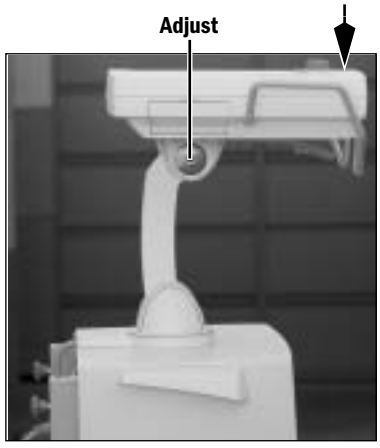
- The pivot covers are held in place by three tabs in the locations shown by the arrows.
- Slide a thin blade between the cover and the pivot housing to release each tab.



To access the adjustment screw for the arm mount bearing, remove the display arm cover.

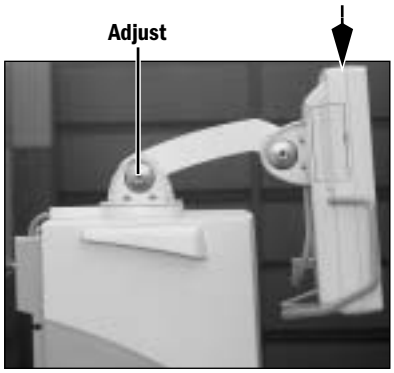
9.5.1 Adjust upper pivot

1. Position the DU as shown:
   - Arm vertical
   - DU horizontal
2. Release the DU.
   - Verify that the DU does not sag from its own weight.
3. Push down slightly at the front of the DU.
   - The DU should remain in place.
4. Verify that the DU can be tilted without excessive force.
5. Adjust the upper pivot as necessary.



9.5.2 Adjust lower pivot

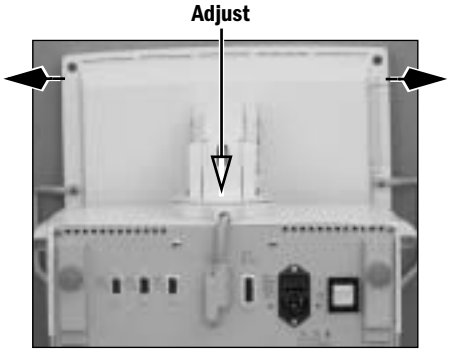
1. Position the DU as shown:
   - Arm forward
   - Upper and lower pivots in line horizontally
   - DU vertical
2. Release the DU.
   - Verify that the DU does not sag from its own weight.
3. Push down slightly at the top of the DU.
   - The DU should remain in place.



4. Verify that the DU can be raised and lowered without excessive force.
5. Adjust the lower pivot as necessary.

9.5.3 Adjust arm bearing

1. Position the DU as shown above:
   - Arm forward
   - Upper and lower pivots in line horizontally
   - DU vertical
2. Move the DU side to side.
   - Verify that the DU can be moved without excessive force and that it remains in place with slight sideways pressure.
3. Adjust the bearing as necessary.



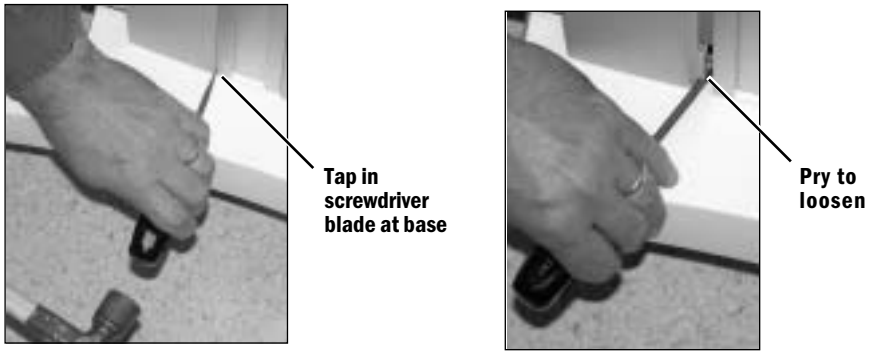
9.6 Removing a compressor from the cart

In routine cases, the compressor can be serviced without removing it from the cart. Refer to the EVair03 Air Compressor Technical Reference manual (6189655).

In situations where greater access to components is required, the compressor can be removed from the cart for service.

⚠ **WARNING** To avoid personal injury, two people are required to remove and install the compressor.

1. Remove the trim pieces from the side extrusions.



2. Remove the compressor mounting hardware from each side of the cart.
3. Screw in a lifting handle (service tool #5370055) into each side of the compressor.

4. With a person on each side of the cart, lift the compressor slightly and slide it forward out of the cart.

⚠ **CAUTION** To avoid tipping, use care when moving the ventilator with the compressor removed from the cart.

Notes

10 Illustrated Parts

In this section

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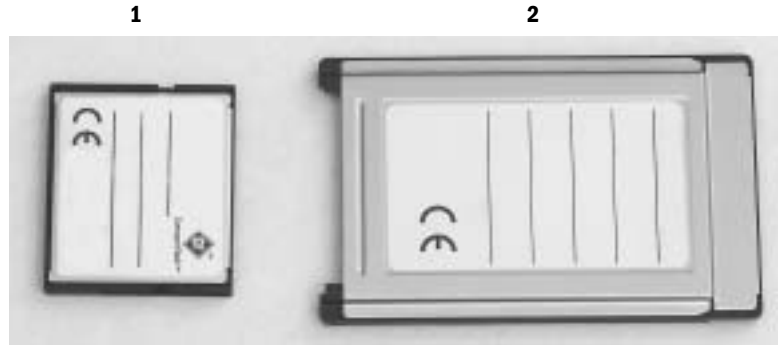
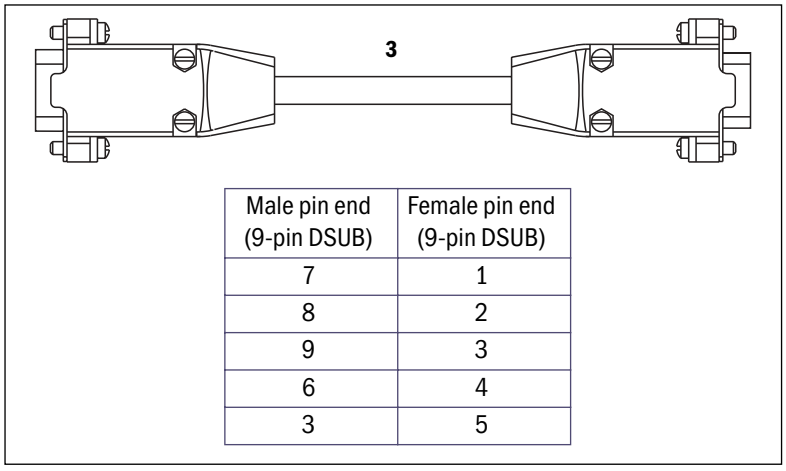
10.1 Service tools

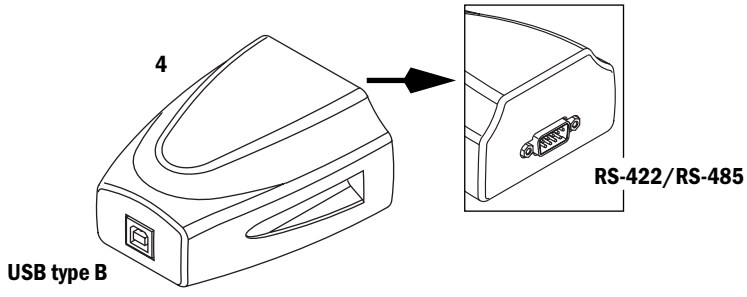
10.1.1 Software tools

Item	Description	Stock Number
1	Service Application/System Software 1.X (on Compact Flash card)	1505-8000-000
2	Compact Flash Adapter, PCMCIA carrier	1009-5874-000
	Windows based EV Service Application	1505-8001-000
3	Cable, USB Converter to EV	1505-8587-000
4	Converter, USB to RS-422/RS-485 (includes USB cable)	1505-8586-000



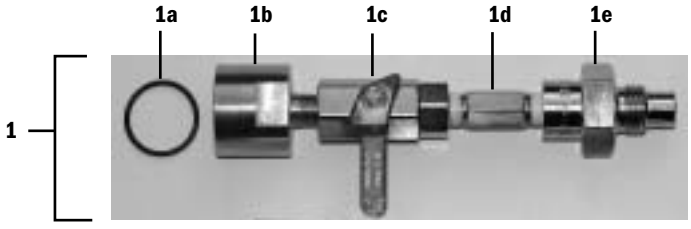


Male pin end (9-pin DSUB)	Female pin end (9-pin DSUB)
7	1
8	2
9	3
6	4
3	5



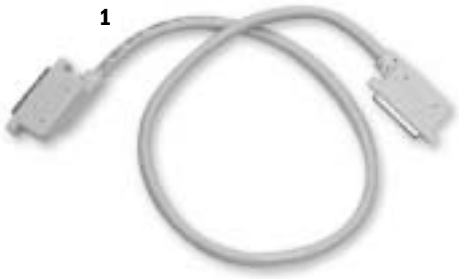
10.1.2 Manual shut-off valves

Item	Tool	Stock Number
1	Manual shut-off valve – O_2	1505-8578-000
	Manual shut-off valve – Air	1505-8579-000
	1a – O-ring,	1006-3614-000
	1b – Adapter, O_2 M18	1505-8576-000
	1b – Adapter, Air M16	1505-8577-000
	1c – Valve, two-way	0207-6023-300
	1d – Nipple, 1/8 NPTM 1 L – O_2	0213-5025-335
	1d – Nipple, 1/8 NPTM 1.5 L – Air	0213-5026-500
	1e – Filter body, M18 – O_2	1001-5921-000
	1e – Filter body, M16 – Air	1001-5923-000



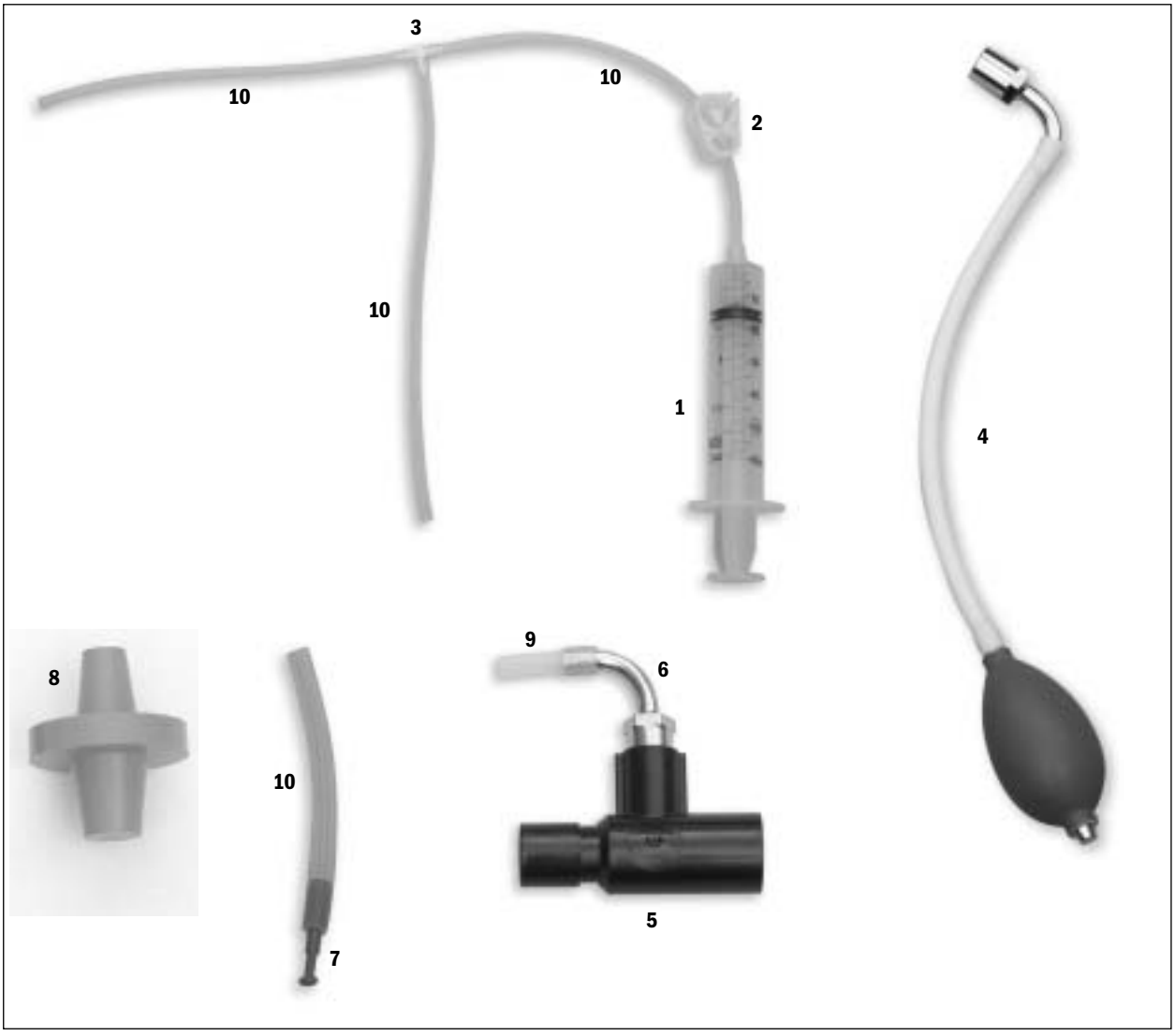
10.1.3 Special tools

Item	Description	Stock Number
1	Cable, Display Unit (connect DU to EV chassis when disassembled for repair and evaluation - Refer to section 9.3)	1505-5600-000
2	Tool, Nebulizer connector (Refer to section 10.10)	1505-8506-000
3	Handle, Service EVair Compressor – two required (Refer to section 9.6)	5370055



10.1.4 Leak test devices

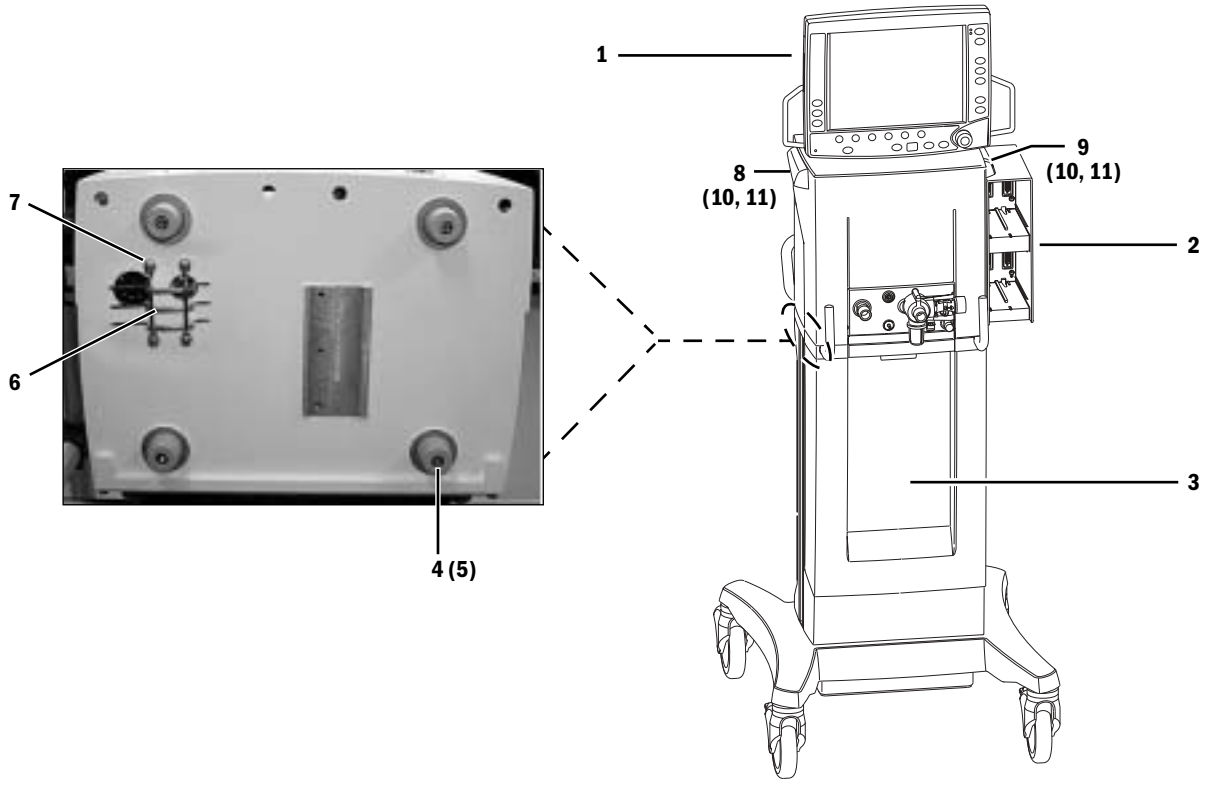
Item	Tool	Stock Number
	Leak test device kit (includes items 1 through 10)	1505-8590-000
1	Syringe, 60 cc	1505-3061-000
2	Clamp, tubing	7000-0000-097
3	Tee, 1/8 inch barb	7000-0000-186
4	Negative low-pressure leak test device	0309-1319-800
5	Tee, sensing 22-mm to 15-mm	0212-0763-100
6	Connector, Endo tube	0219-5060-530
7	Plug, 4-mm	1006-3530-000
8	Plug, stopper (2)	2900-0001-000
9	Silicone tubing 3/16 ID	1006-3666-000
10	Tubing, clear 0.125 ID	0994-6370-010



10.1.5 Lubricants and Adhesives

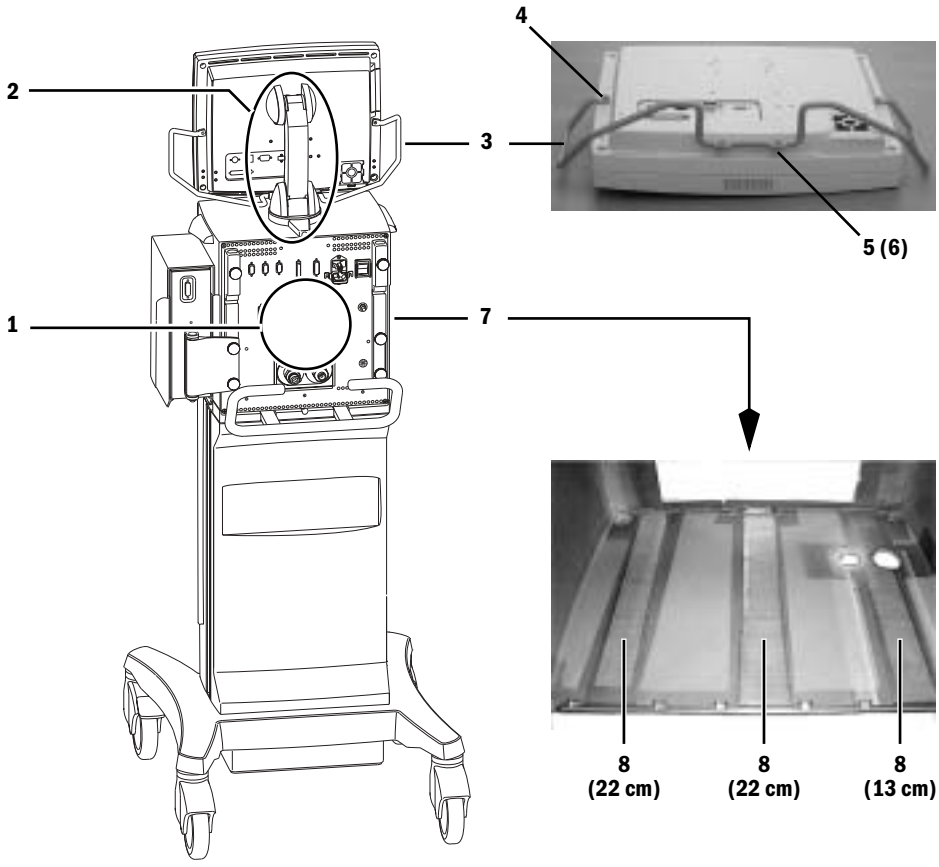
Item	Description	Stock Number
1	Lubricant, Krytox GPL 205, 2 oz	1001-3854-000
2	Thread Lock, Loctite No 24221 (medium strength), 10 ml	0220-5017-300
3	Thread Lock, Loctite No 271 (high strength), 10 cc	0220-5021-300

10.2 External components - front view



Item	Description	Stock Number
1	Display Unit	Refer to section 10.6
2	Module rack	Refer to section 10.15
3	Cart	Refer to section 10.14
4	Foot, Vent Housing	1505-3430-000
5	Screw, M5x20 SKT HD	0144-2131-919
6	Cage, air transfer	1505-3250-000
7	Screw, M4x8 Pan HD	9211-0440-083
8	Handle Left Vent Housing	1505-3429-000
9	Handle Right Vent Housing	1505-3428-000
10	Screw M4x10 Pan Hd Pozidriv	0144-2117-722
11	Washer M4 external	9213-0540-003

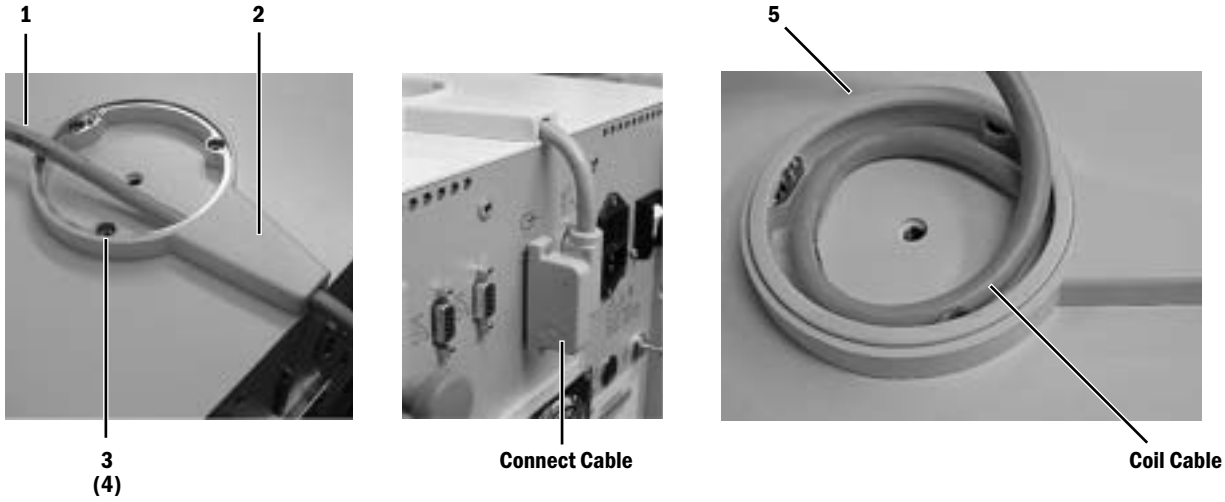
10.3 External components - rear view

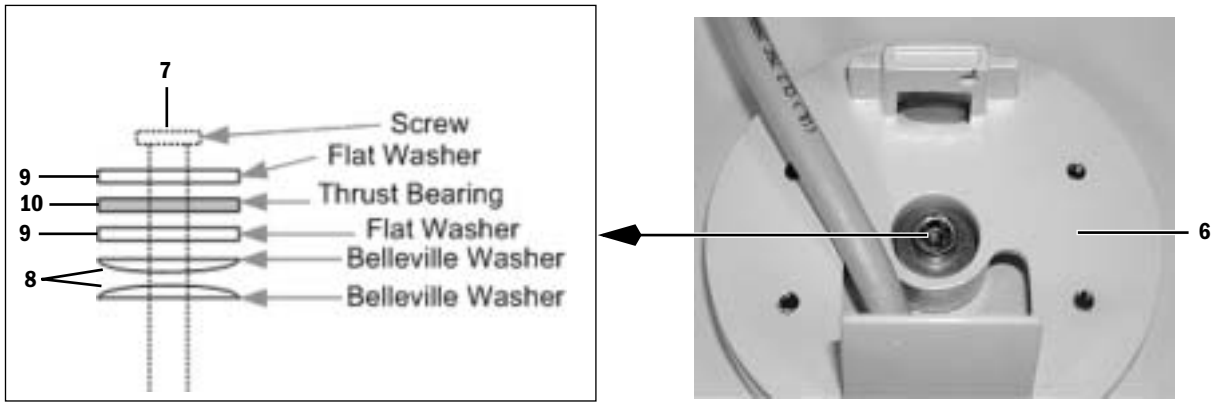


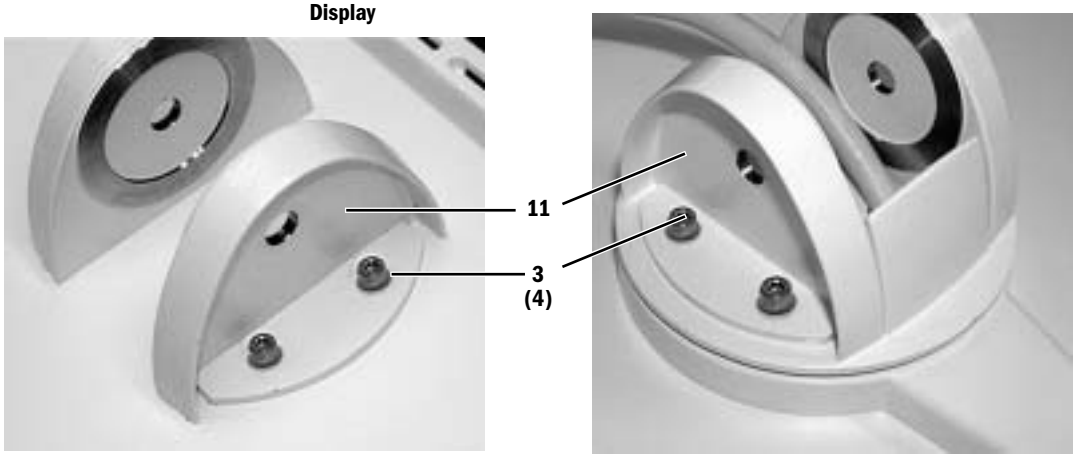
Item	Description	Stock Number
1	Main enclosure (external) Main enclosure (internal)	Refer to section 10.7 Refer to section 10.8
2	Display arm mounting hardware Display arm assembly	Refer to section 10.4 Refer to section 10.5
3	Guard, DU connector	1505-3419-000
4	Screw, M4x12	0140-6226-111
5	Spacer, connector guard	1505-3434-000
6	Screw, M4x25	0140-6226-125
7	Housing, Vent	1505-3403-000
8	Tape, Wear UHMW Polyethylene	1505-3030-000

10.4 Display arm mounting hardware

Item	Description	Stock Number
1	Cable, Display Unit	1505-5600-000
2	Base Display Arm Mount	1505-3415-000
3	Screw M4-0.7 x 8 SHCS	9211-0640-083
4	Washer, M4 Flat	0144-1025-165
5	Bearing Rotate Display Arm	1505-3418-000
6	Plate Rotate Display Unit	1505-3414-000
7	Screw M6x20 SHCS w/Nylon Strip	1505-3038-000
8	WASHER BELLEVILLE SMALL	1505-3017-000
9	Washer Thrust Steel 6.35ID 17.45OD 1.56THK	1505-3021-000
10	Bearing Thrust	1505-3020-000
11	Mount Pivot Display Unit	1505-3412-000

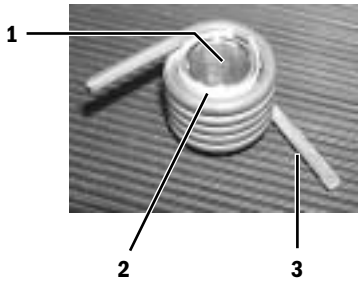

1
2
3
(4)
Connect Cable
5
Coil Cable


7
Screw
Flat Washer
9
Thrust Bearing
10
Flat Washer
9
Belleville Washer
8
Belleville Washer
6


Display
11
3
(4)

10.5 Display arm assembly

Item	Description	Stock Number
1	Mandrel Display Arm Spring	1505-3417-000
2	Sleeve Display Arm Spring Mandrel	1505-3431-000
3	Spring Torsion Display Arm	1505-3016-000
4	Arm Display	1505-3410-000
5	Bearing Tilt Display Arm	1505-3416-000
6	Screw M8x60 SHCS	1505-3018-000
7	WASHER BELLEVILLE BIG	1505-3040-000
8	Nut M8 keps	0144-3717-348
9	Cover Display Arm	1505-3411-000
10	Screw M3-0.5 x 6 Pan Hd Pozidriv Sems s/s	0140-6219-128
11	Cover Display Unit Pivot Mount	1505-3413-000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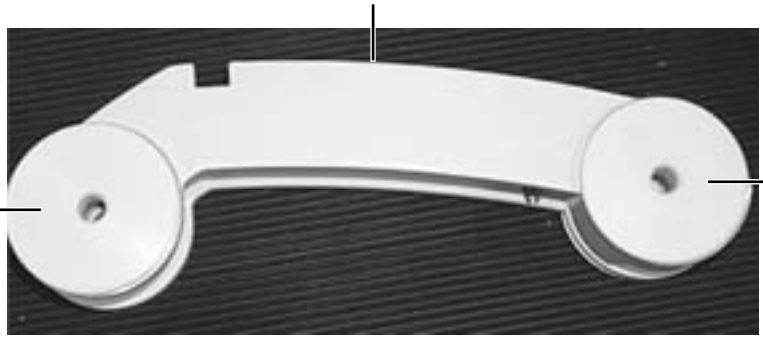
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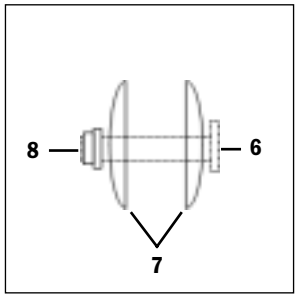
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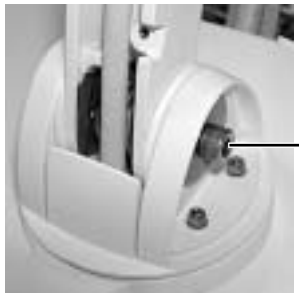
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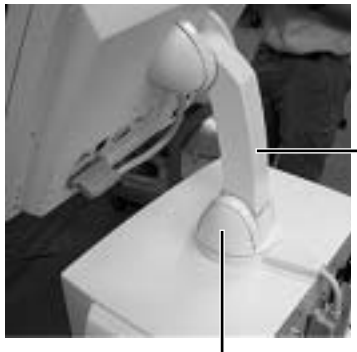

9
(10)
11

10.6 Display Unit

Item	Description	Stock Number
	Display Assembly, complete, without keypads	1505-3433-000
1	Enclosure, rear	1009-5673-000
2	CPU Board, display unit (with PCMCIA frame)	1009-8289-000
3	Frame, PCMCIA	1009-5761-000
4	Gasket, knife edge (2 each)	1009-5804-000
5	Battery, Lithium 3V (positive side up)	1009-5800-000
6	Display, DG41, LCD 12-inch color (includes backlights)	1009-5938-000
7	Backlight Kit, DG41 (backlight assembly, 2 inverters, and hardware)	1009-8422-000
7a	Inverter, backlight	1009-5694-000
7b	Harness, inverter	1009-5527-000
7C	Spacer, 8mm Nylon	1009-5695-000
8	Grommet, diagonal cut (backlight cable)	1009-3152-000
9	Enclosure, front	1505-3424-000
10	Gasket, EMC 1.8mm OD hollow RND (2.3 m per enclosure)	1009-5802-000
11	Window	1009-5676-000
12	Encoder assembly	1503-3012-000
13	Knob, soft touch GEMS steel blue	1609-3090-000
14	Membrane switches, right	1009-5505-000
15	Membrane switches, lower	1009-5507-000
16	Membrane switches, left	1009-5506-000
17	Keypad, right-side (part of keypad set)	Refer to Table 1
18	Keypad, lower (part of keypad set)	Refer to Table 1
19	Keypad, left (part of keypad set)	Refer to Table 1
20	Speaker assembly, 8-ohm	1605-3263-000
21	Rear Connector Panel Assembly (with interface boards)	1505-8507-000
22	Cable, ribbon CPU to Display	1009-5520-000
23	Grommet	1009-3151-000
24	Fan, 5Vdc	1504-3516-000
25	Capsule, fan filter	896089
26	Filter, fan	897010
27	Door, PCMCIA	1009-5679-000
28	Gasket, cover plate	1009-5678-000
29*	Screw, M3x6 Sems	0140-6219-128
30*	Screw, M4x8 Sems	0140-6226-113
31*	Screw, M4x12 relieved body	1504-3001-000
32*	Lockwasher, M4 external	9213-0540-003
33*	Screw, M3x16	1504-3003-000
34*	Lockwasher, M3 external	9213-0530-003
35*	Screw, M3x6 Nylon	9211-1730-065
36*	Screw, M2x16	0140-6216-100

* Refer to Table 2 for where used.

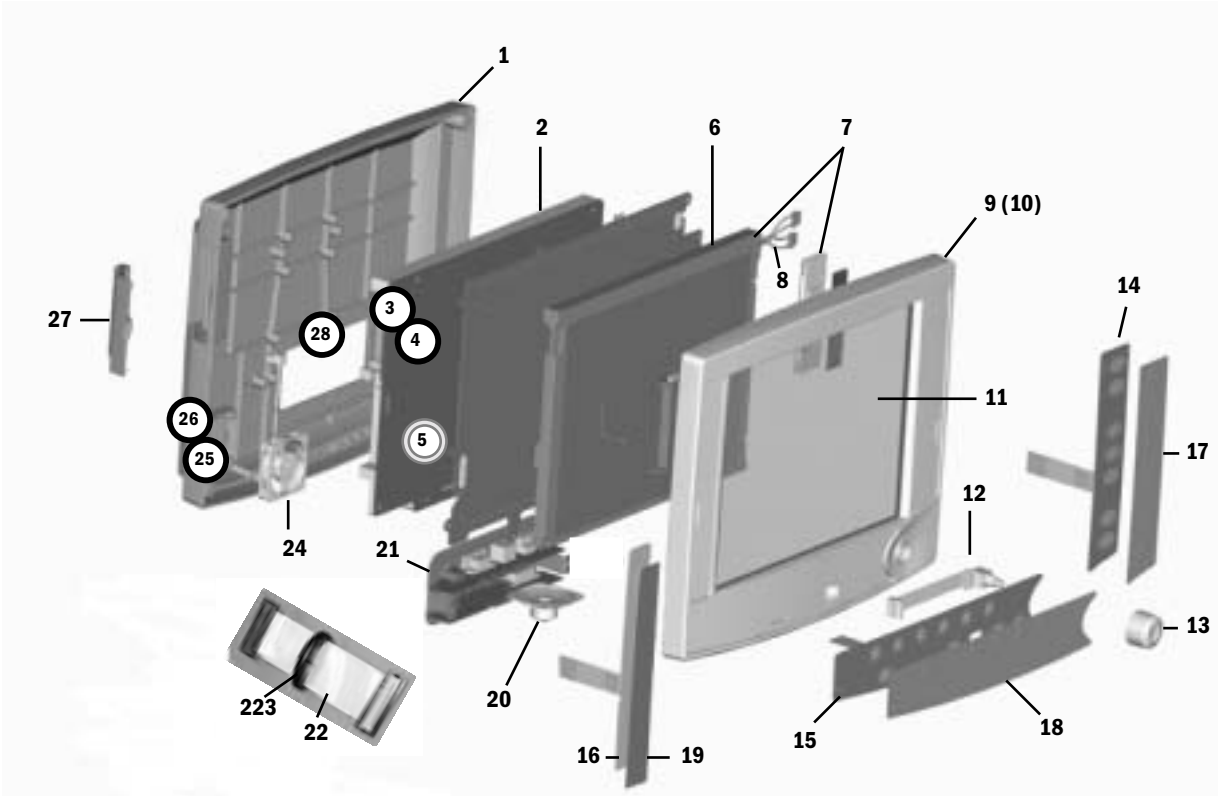


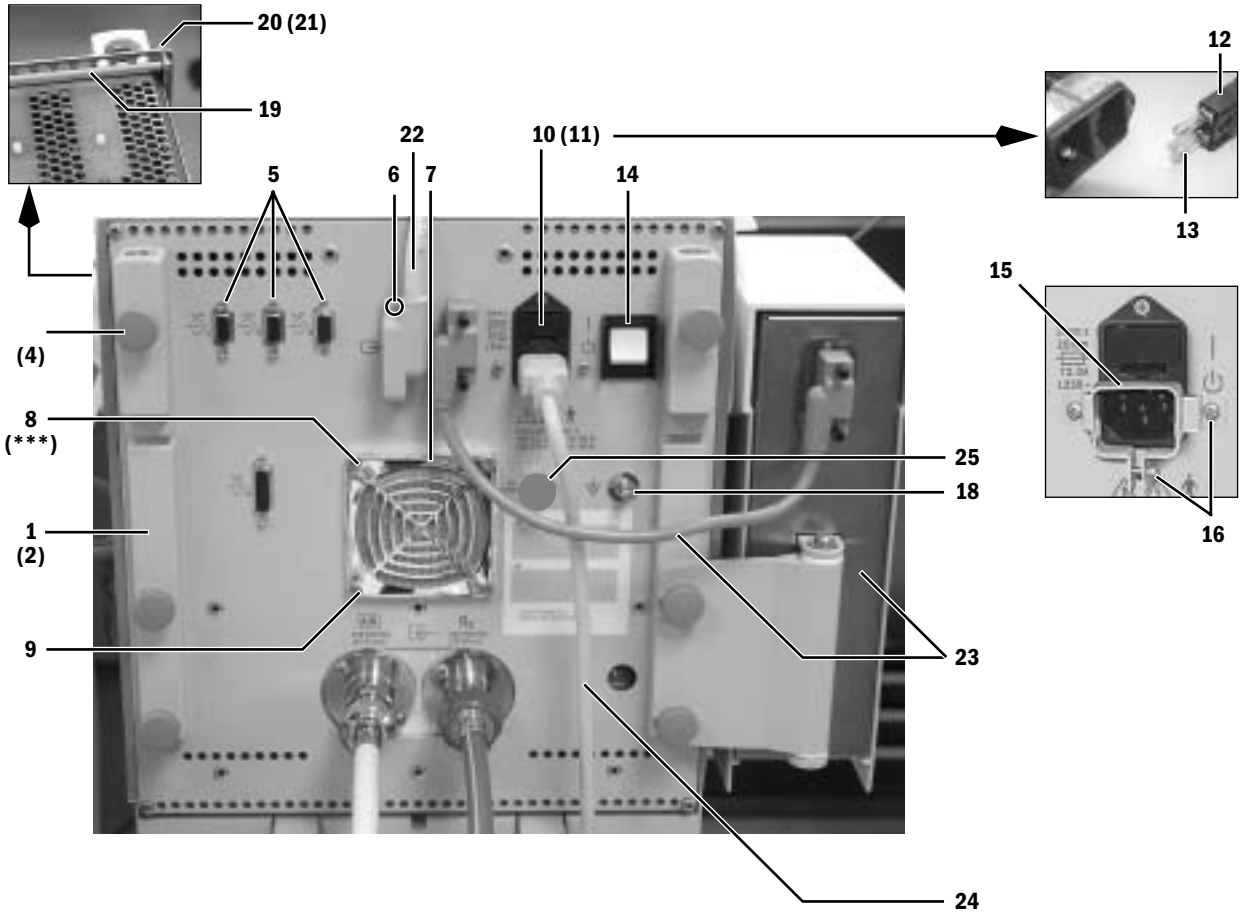
Table 1:	
Language	**Keypad Set**
Chinese	1505-3453-000
Czech	1505-3443-000
Danish	1505-3452-000
Dutch	1505-3438-000
English	1505-3435-000
Finnish	1505-3442-000
French	1505-3436-000
German	1505-3437-000
Greek	1505-3447-000
Hungarian	1505-3448-000
Italian	1505-3439-000
Japanese	1505-3449-000
Norwegian	1505-3445-000
Polish	1505-3444-000
Portuguese	1505-3441-000
Russian	1505-3451-000
Spanish	1505-3440-000
Swedish	1505-3450-000
Turkish	1505-3446-000

Table 2:
Hardware Item where used (Qty)
Speaker: 29(2)
Door: 29(2)
CPU to plate: 30(4)
Rear connector panel assembly: 30(2)
Ground straps for keypads: 30(2)
Mounting plate to Front enclosure: 30(10)
Rear enclosure: 31(4), 32(4)
Fan: 33(4), 34(4)
Inverters: 35(4)
PCMCIA frame: 36(4)

10.7 Main enclosure (external)

Item	Description	Stock Number
1	Mount Arm/PM Module Rack	1505-3409-000
2	Screw, M4x8	0144-2436-108
3	Screw Thumb M6x16	1505-3005-000
4	Ring, Retaining External 4.8 SFT SST	1505-3035-000
*5	STDF Screwlock, #4-40 Female	1504-3007-000
6	Jacksocket, M2.5/M2 SST	1505-3023-000
7	Filter Guard (includes media), Fan 80MM	1505-3027-000
7a	Filter media	1505-3029-000
8***	Screw M3x20 CTSK SKT HD	1505-3056-000
9	Screw M3x40 CTSK SKT HD	1505-3057-000
10	AC Inlet, Filter with fuseholder	1505-5001-000
11	Screw M3-0.5x8 Flat Head Pozidriv	9211-0530-083
12	Fuse Drawer, AC Inlet	1505-5002-000
13	Fuse, 2A 250V 5X20 mm Delayed Time	1503-3073-000
14	Switch, On/Standby DPST	1605-3043-000
15	Retainer, Power Cord	1505-3033-000
16	Screw, M3x8 POSI PAN HD SEMS SST	0140-6219-130
18	Stud Equal Potential	0208-0070-300
**19	Gasket EMI 3x4 with pressure sensitive adhesive	1505-3002-000
20	M4-0.7x12 Pozidriv Pan Hd Relieved SST	1504-3001-000
21	Lockwasher, M4 Internal	0144-1118-128
22	Cable, Display Unit	Refer to section 10.4
23	Cable, Patient Module Rack	Refer to section 10.15
24	Cable, AC Power Cord	Refer to section 10.12
25	Plug	1505-3015-000

* Apply Loctite 271.
** Total length = 1230 mm (300 mm top/bottom – 315 mm sides).
*** Item 8 retained with nut on inside of chassis (Refer to section 10.8).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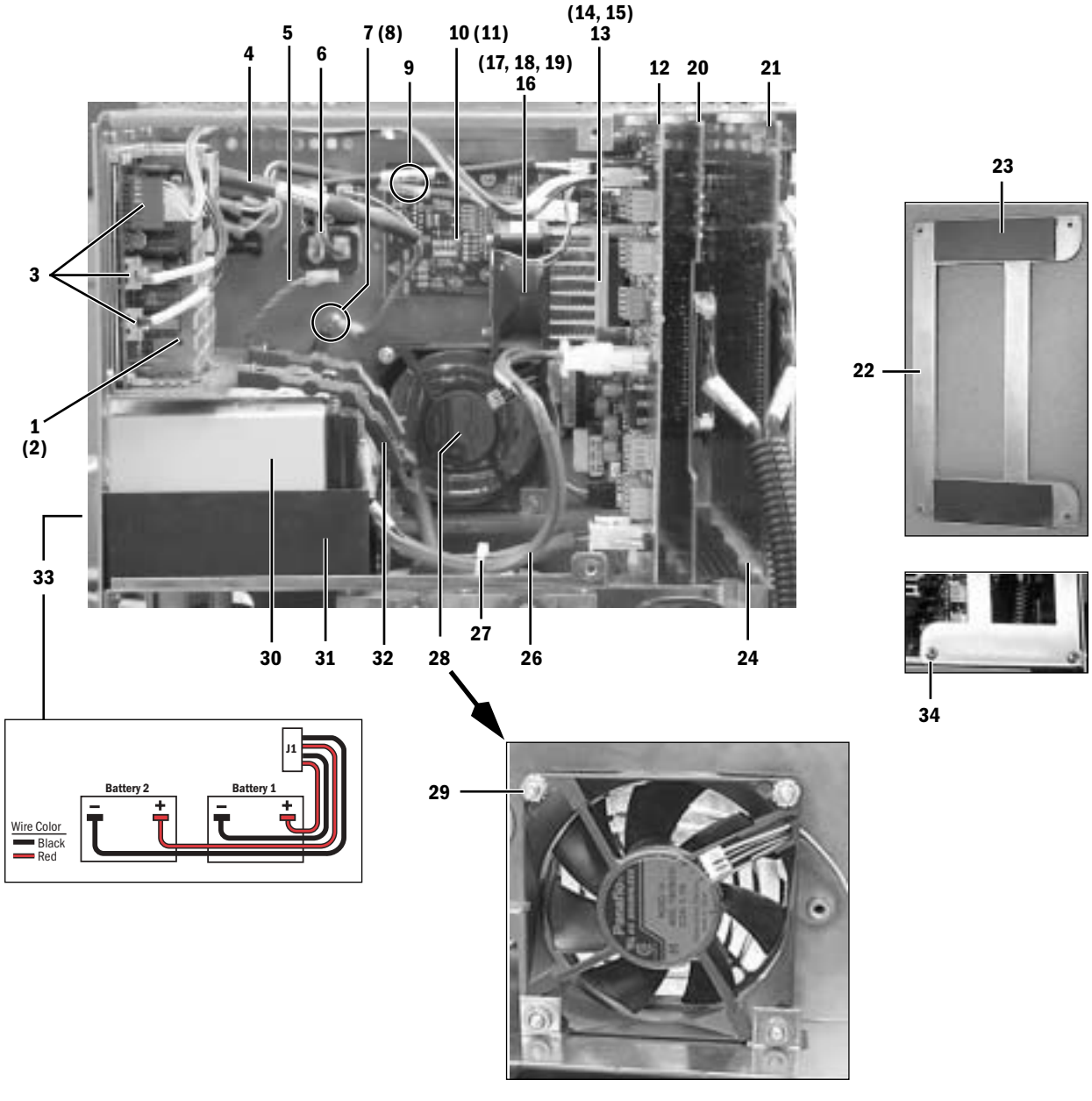
9
23
24

10.8 Main enclosure (internal)

Item	Description	Stock Number
1	Power Supply Module	1505-5000-000
2	Screw 4-40x3/16 Pozidriv Pan Sems	1505-3004-000
3	Harness (Power Supply to PMB)	1505-5700-000
4	Harness (AC Inlet to Power Supply)	1605-3261-000
5	Wire, chassis safety ground	1605-3060-000
6	Harness, Jumper AC Inlet	1505-5718-000
8	Lockwasher, M4 external	9213-0540-003
9	Harness (On/Standby)	1605-3059-000
10	Motherboard	1505-5504-000
11	Screw, M4X6 PAN HD SEMS	1505-3000-000
12	Power Management Board (PMB)	1505-5502-000
13	Heat Sink	1505-5004-000
14	Screw, M3-0.5x20 Pan HD Pozidriv	0140-6719-103
15	Lockwasher, M3 external	9213-0530-003
16	Fan, 24Vdc 14CFM with harness	1505-3025-000
17	Screw, M3x50 Pan Hd Pozidriv SST	1505-3037-000
18	Lockwasher, M3 Split Lock SST	1505-3036-000
19	Washer, 3.18ID 8.64OD 0.76T SST	1006-5234-000
20	Vent Monitor Board (VMB)	1505-5501-000
21	Vent Control Board (VCB)	1505-5500-000
22	Retainer, PCA/CARD CAGE	1505-3401-000
23	Foam, 3.18 THK 12.7W X 90L EPDM	1505-3402-000
24	Guide, Card	1505-3001-000
26	Harness (battery to PMB)	1505-5702-000
27	Tie Wrap	0203-5915-300
28	Fan, 24VDC 39.6CFM with harness	1505-3024-000
29	Nut, M3 Keps	0144-3717-302
30	Battery (Internal)	1009-5682-000
31	Battery Tray	1009-3133-000
32	Strap, Battery Restraint	1504-3509-000
33	Label, Battery Service Instruction	1009-5530-000
34	M4-0.7x12 Pozidriv Pan Hd Relieved SST	1504-3001-000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10 (11)
(17, 18, 19)
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(14, 15)
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12
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1
(2)
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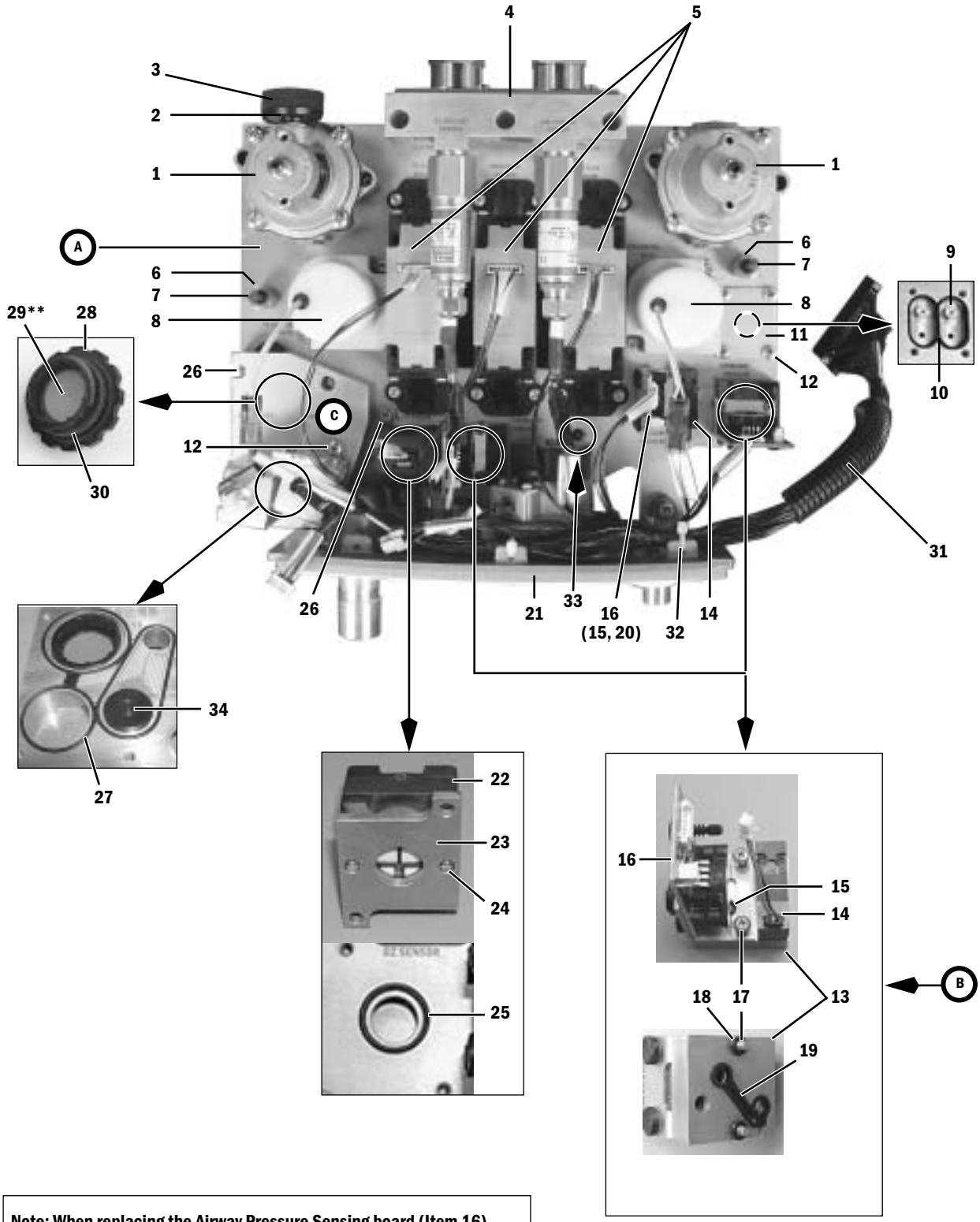
30
31
32
28
27
26
24
23
22
34
29
J1
Battery 2
Battery 1
Wire Color
Black
Red

10.9 Vent Engine

Item	Description	Stock Number
A	Manifold, Main Assembly (does not include mounted components)	1505-8504-000
1	Regulator w/screws	1505-3256-000
	O-ring, EPR, 2-012	1503-3056-000
*2	Port, Regulator	1505-3260-000
3	Gasket, Port	1505-3261-000
4	Inlet manifold	Refer to section 10.11
	O-ring, EPR, 2-016	1006-3616-000
	Screw M5-0.8x30 SHCS	1102-3049-000
5	Transducer Flow 0-160 LPM	1505-3208-000
	O-ring, EPR, 2-018	0210-0684-300
6	Fitting 4mm G1/8 Self Sealing Legris	1505-3266-000
7	Plug 4mm dia Legris	1006-3530-000
8	Valve Flow Control 160 LPM	1505-3209-000
	O-ring, EPR, 2-012	1503-3056-000
9	Restrictor, Pneumatic	1505-3218-000
10	Gasket, Pneumatic restrictor	1505-3220-000
11	Plate, Pneumatic restrictor	1505-3219-000
12	Screw M4x8 Pan Hd Pozidriv	9211-0440-083
B	Pressure Sensor Assembly, expiratory - inspiratory (includes Items 13 through 19)	1505-8503-000
13	Manifold Zeroing Valve	1505-3248-000
14	Valve Zeroing 3/2	1505-3249-000
15	O-ring, EPR, 2-007	1006-3213-000
16	PCA Airway Press Sens Board (see Note on following page)	1505-5506-000
17	Screw M3-0.5x16 Pan Hd Pozidriv	1504-3003-000
18	O-ring, Buna-N, 2-005	1009-3306-000
19	Gasket Zeroing Valve	1505-3211-000
20	Screw M3-0.5 x 6 Pan Hd Pozidriv Sems s/s	0140-6219-128
21	Outlet manifold	Refer to section 10.10
	O-ring, EPR, 2-016	1006-3616-000
	O-ring, EPR, 2-012	1503-3056-000
	Screw M5-0.8x20 SHCS	0144-2131-919
22	Transducer O2 CONC	1505-3215-000
23	Plate, O2 Sensor	1505-3247-000
24	Screw M2 x 6 Pan Hd Pozidriv SST	0140-6712-102
25	O-ring, VITON, BS 4518 0171-16	1505-3059-000
26	Screw M4-0.7x12 SHCS	1102-3006-000
27	Gasket Inspiratory Manifold	1505-3262-000
28	Valve Seat Free Breathing	1503-3204-000
29**	Valve Flapper (Free Breathing)	0211-1454-100
30	O-ring, EPR, 2-126	1503-3208-000
31	Harness (vent engine to VCB/VMB)	1505-5706-000
32	Tie Wrap	0203-5915-300
33	Valve Umbrella Check	1505-3267-000
34	Seal, safety valve	1505-3254-000
C	Manifold, Insp Valve Assembly (includes effort valve and safety valve actuator; does not include safety valve seal)	1505-8502-000

* Apply Teflon tape to threads.

** Install the flapper valve from the threaded side of the valve seat. Trim the tail piece close to the outside surface of the seat (refer to removed flapper).

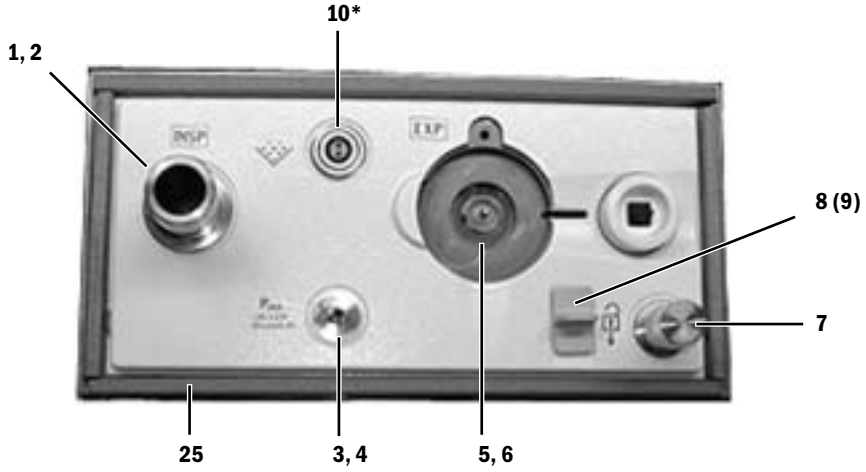


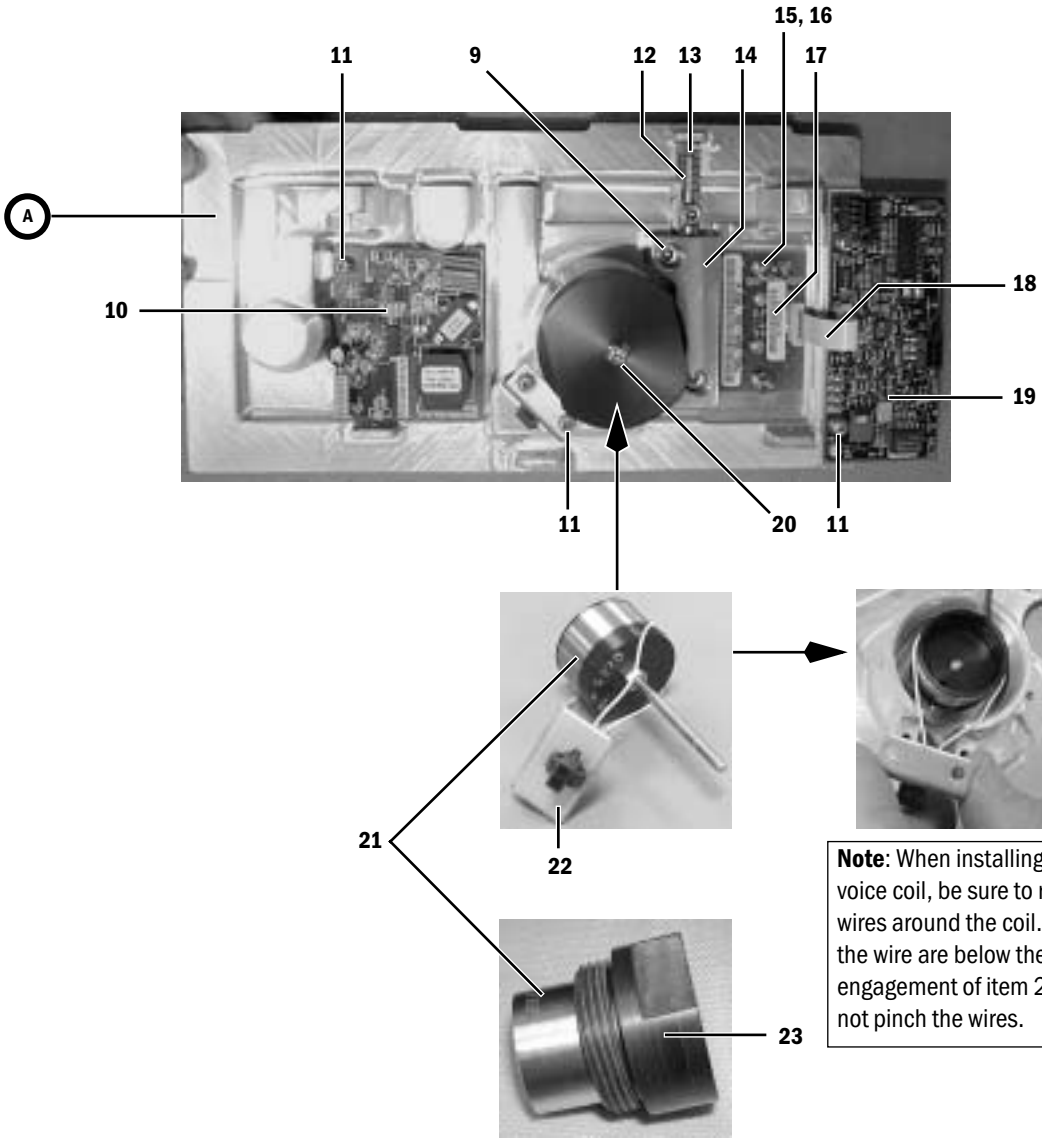
Note: When replacing the Airway Pressure Sensing board (Item 16), ensure that the o-ring (Item 15) is properly seated in the manifold before mounting the board in place.

10.10 Outlet manifold

Item	Description	Stock Number
A	Outlet Manifold Panel Assembly; includes EMI gasket (does not include mounted components)	1505-8505-000
1	PORT INSP	1505-3216-000
2	O-ring, 2-016, EPR	1006-3616-000
3	PORT AUX PRESS	1505-3217-000
4	O-ring, 2-011, EPR	017-923
5	SEAL ROLLING SHAFT	1505-3225-000
6	RING RETAINING	1406-3540-000
7	PORT OCCLUSION OUTLET MANIFOLD	1505-3259-000
8	PULL EXH HOUSING LATCH	1505-3236-000
9	Screw M4-0.7x12 SHCS	1102-3006-000
10*	PCA ULTRASONIC NEB CONTROL	1505-3251-000
11	Screw M3-0.5x6 Pan Head Pozidriv Sems SST	0140-6219-128
12	SPRING EXH HOUSING LATCH	1505-3237-000
13	ROD EXH HOUSING LATCH	1505-3238-000
14	HOUSING EXH HOUSING LATCH	1505-3239-000
15	Screw Shoulder M3x0.5-12.7 SS	1011-3147-000
16	SPRING COMPRESSION 6.1 OD 12.7L	1006-3735-000
17	PCA EXH FLOW INTERFACE BRD	1505-5508-000
18	Cable Exh Flow Sensor	1505-5603-000
19	PCA EXH FLOW SNSR BRD	1505-5507-000
20	Screw 6-32 x 1/4 PH Pan Hd SST	0140-6524-102
21	ACTUATOR VOICE COIL	1505-3227-000
22	BRACKET VOICE COIL CONN	1505-3228-000
23	ADAPTER VOICE COIL MAGNET	1505-3230-000

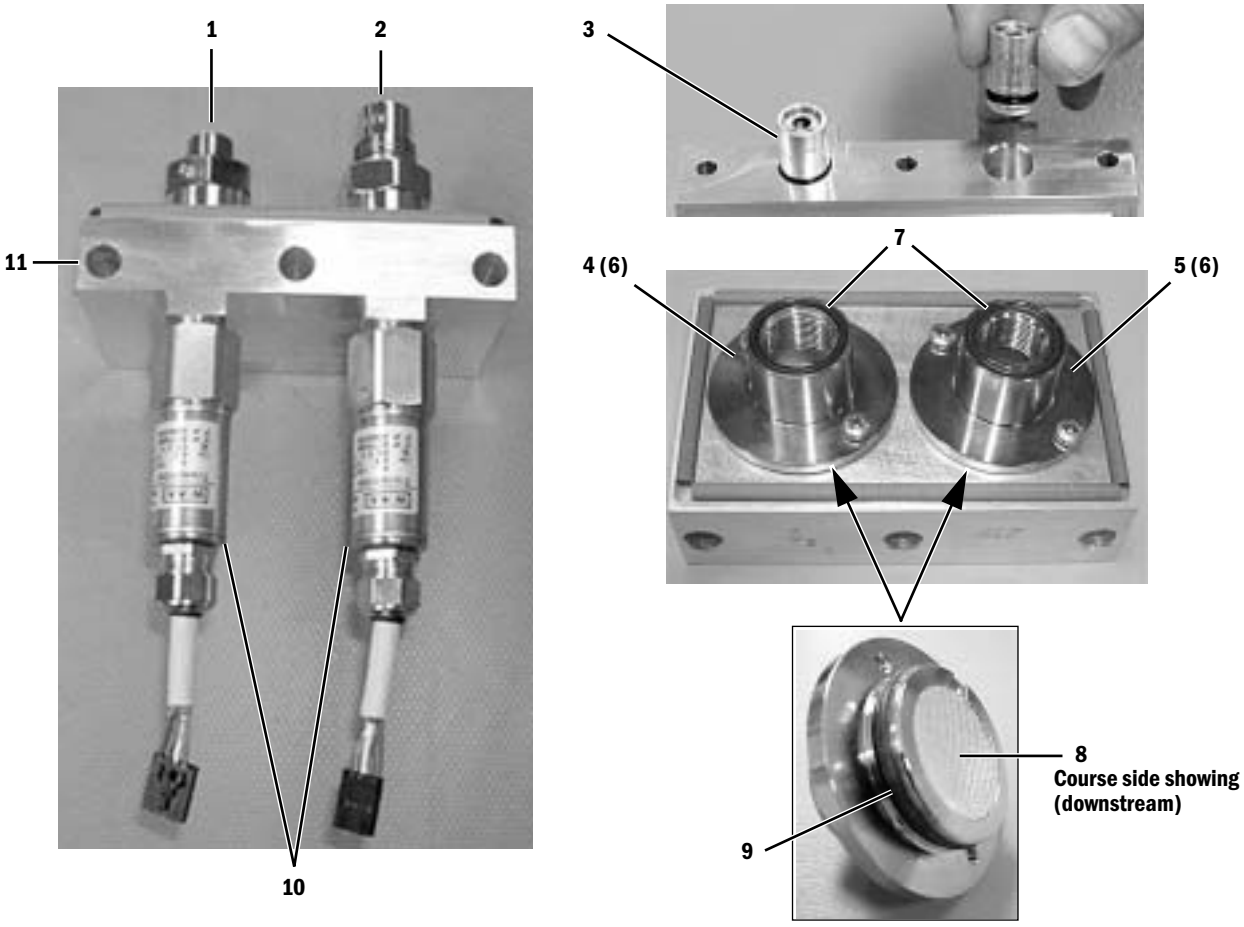
* Use special tool (Refer to section 10.1.30 to remove collar from Nebulizer connector. Apply Loctite 271 to treads of connector when replacing collar.





Note: When installing the voice coil, be sure to route the wires around the coil. Ensure the wire are below the thread engagement of item 23. Do not pinch the wires.

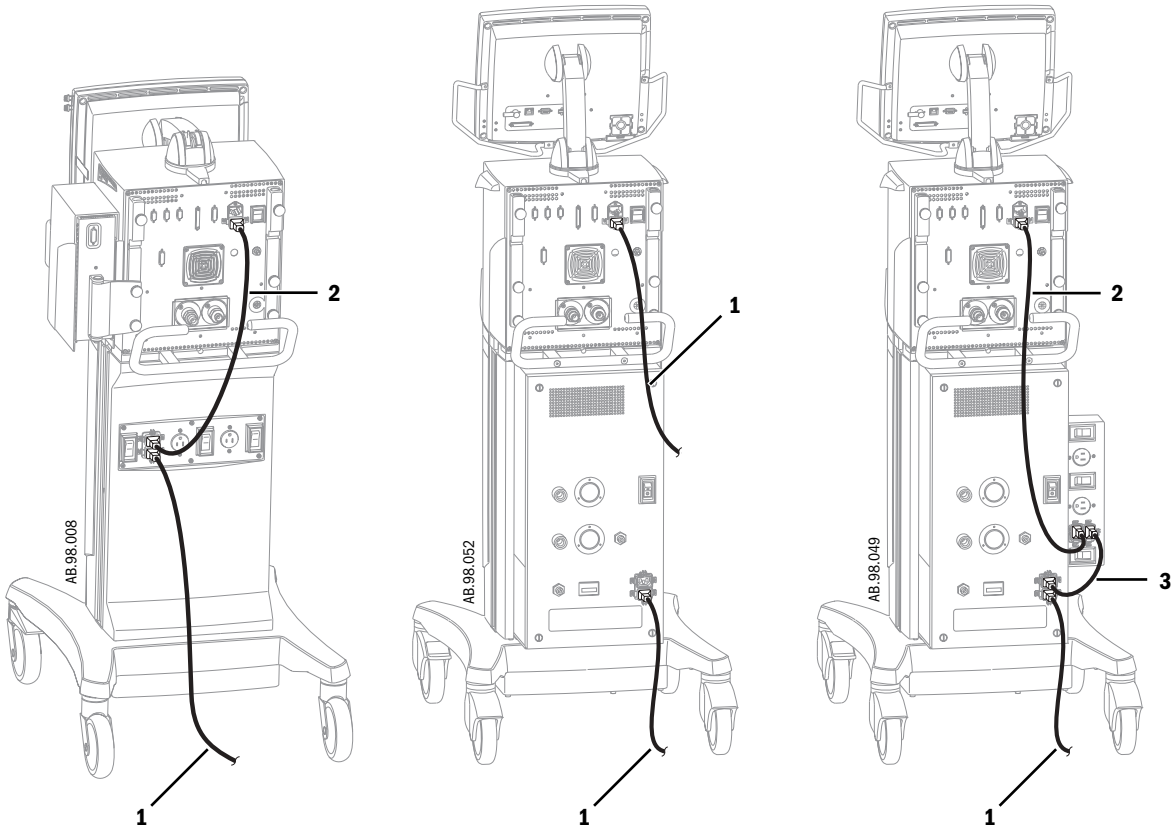
10.11 Inlet manifold

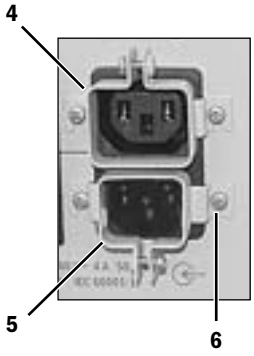


Item	Description	Stock Number
1	Inlet fitting, O_2	Refer to Table 1
2	Inlet fitting, Air	Refer to Table 1
3	Check Valve	1006-3430-000
4	Adapter, 02 Pipeline	1505-3206-000
5	Adapter, Air Pipeline	1505-3207-000
6	Screw, M4-0.7x12 Pozidriv Pan Hd Relieved SST	1504-3001-000
7	O-ring, OD23.9 ID20.35 EPDM DURO70 -019	1006-3614-000
8	Filter Disc, Wire Mesh 2 Micron	1504-3708-000
9	O-ring, EPR 2-122 70 DURO	1504-3612-000
10	Transducer, Pressure 827 kPa (120 psi)	1011-3413-000
11	Manifold (includes EMI gasket)	1505-8501-000

Table 1: Inlet Fitting	Stock Number	
	1 - O_2	2 - Air
DISS	9913-6489-400	9913-6557-800
DISS Female	1505-3851-000	1505-3830-000
NIST	1001-5967-000	1001-5826-000
S90-116; fitting seal	1010-7046-000 1010-3220-000	1010-7048-000 1010-3220-000
SIS	1505-3852-000	1505-3831-000

10.12 AC power cords

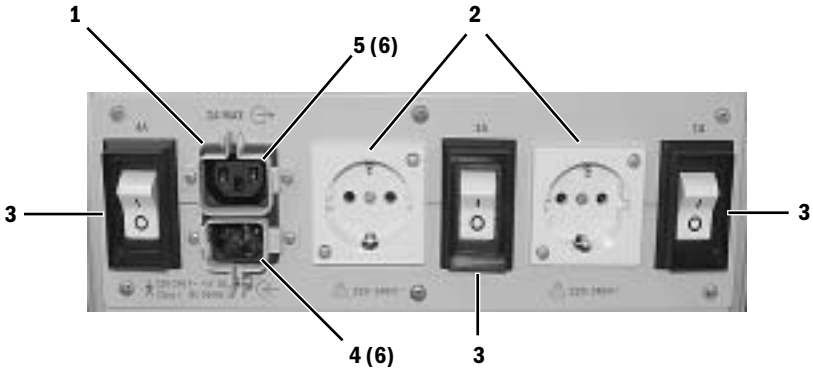


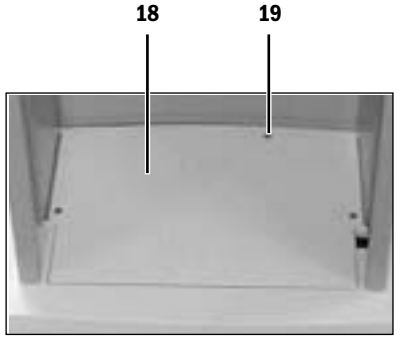


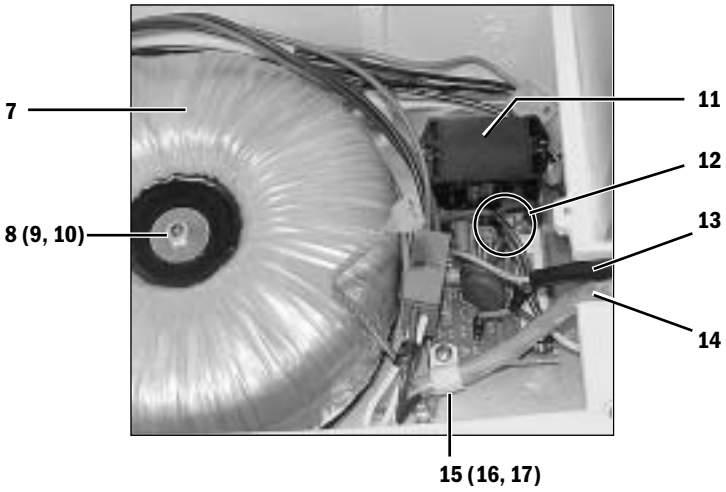
Item	Description	Stock Number
1	Power Cord	
	AS 3112, 220-240 Vac	1500-3561-000
	BS 1363, 220-240 Vac	1500-3283-000
	BS 546, 220-240 Vac	1505-3817-000
	CEE 7/7, 220 Vac	1500-3291-000
	NEMA 5-15, 100-120 Vac	1505-3816-000
	SEV 1011, 220-240 Vac	1500-3292-000
2	Power Cord Jumper, 1.0 meters	1505-3844-000
3	Power Cord Jumper, 0.5 meters	1505-3843-000
4	Retainer, Outlet Power Cord Jumper	1505-3041-000
5	Retainer, Inlet Power Cord	1505-3033-000
6	Screw, M3x8 PAN HD Sems	0140-6219-130

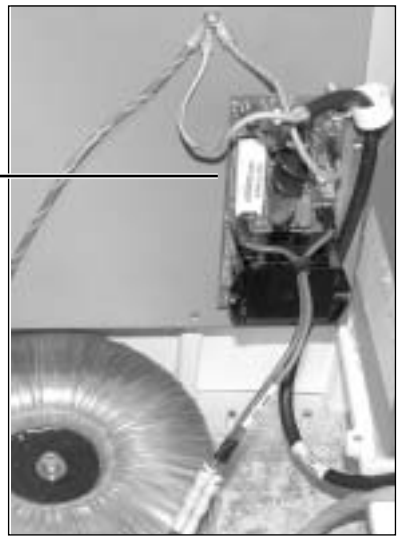
10.13 AC Inlet/Outlet Components

Item	Description	Stock Number
1	AC Inlet/Outlet module	1505-5006-000
2	Outlet Receptacle, Australia, AS 3112	1001-3305-000
	Outlet Receptacle, EURO, CEE 7/7	1202-3551-000
	Outlet Receptacle, France, CEE 7/4	1006-4421-000
	Support Frame, snap in	1006-4422-000
	Outlet Receptacle, India and South Africa, BS 546	1006-3805-000
	Outlet Receptacle, Japanese	1006-3578-000
	Outlet Receptacle, NA, Nema 5-15	1006-3555-000
	Outlet Receptacle, Swiss, SEV 1011	1006-3807-000
	Outlet Receptacle, UK, BS1363	1001-3309-000
3	Circuit Breaker, 1A, Rocker	1009-5722-000
	Circuit Breaker, 2A Rocker	1009-5721-000
	Circuit Breaker, 3A Rocker	1009-5720-000
	Circuit Breaker, 4A Rocker	1009-5719-000
	Circuit Breaker, 6A Rocker	1505-5007-000
4	Retainer, Inlet Power Cord	1505-3033-000
5	Retainer, Outlet Power Cord Jumper	1505-3041-000
6	Screw, M3x8 POSI PAN HD SEMS SST	0140-6219-130
7	Toroid, 100-240V	1009-5692-000
8	Screw, M6x70	0144-2131-923
9	Lockwasher, M6	9213-0560-003
10	Washer	0402-1107-500
11	Circuit board, Inrush, 100-120V	1006-3245-000
	Circuit board, Inrush, 220-240V	1006-3246-000
12	Harness, 100/120 V Inrush to toroid	1505-5709-000
	Harness, 220/240 V Inrush to toroid	1505-5715-000
13	Harness, AC inlet to Inrush	1505-5711-000
14	Harness, to 100/120 V toroid to outlets	1505-5710-000
	Harness, to 220/240 V toroid to outlets	1505-5716-000
15	Cable clamp	1009-3184-000
16	Screw, M4x16 PH PAN HD SST TYPE 316	9211-0440-163
17	Lockwasher, M4 external	9213-0540-003
18	Plate, base cover	1505-3603-000
19	Screw, M4x8 Pozidriv Flat HD	0140-6226-107





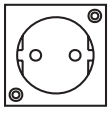




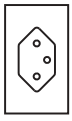
Alternate mounting of Inrush board

AS 3112
Australia/China

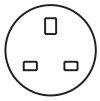
AA.96.228



CEE 7/7
EURO



SEV 1011
Swiss,



BS1363
UK

BS 546
India and South Africa

Nema 5-15
NA

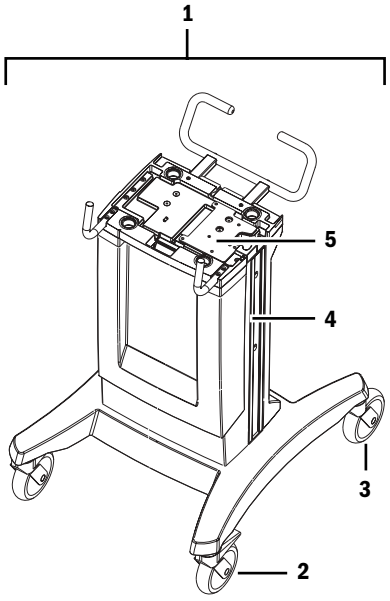
10.14 Cart

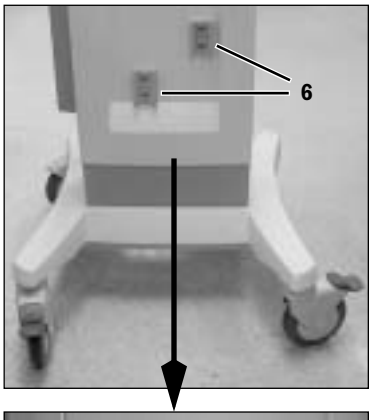
Item	Description		Stock Number
1	Cart Assembly		1505-3600-000
2	Caster Kit, locking		03-11-045
3	Caster Kit, non-locking		03-11-046
4	Extrusion, left		03-11-049
	Extrusion, right		03-11-050
5	Lock Plate Kit		03-11-048
6	Receiver Assembly (hardware included)	Kit includes 1 assembly	1505-3850-000
		Kit includes 2 assemblies	1505-3847-000
7	Panel Assembly, rear		1505-3601-000
8	Bracket, mounting rear panel assembly		1505-3602-000
9	Screw, M6x12 SKT HD CAP		1102-3052-000
10	Panel, outlet blank		1505-3845-000
11	Nut, M4 Keps		0144-3717-314
12	Box, outlet (for carts with compressor)		1505-3833-000
13	Screw, M6x12 Sems		0144-2436-106
14*	Weight		1009-3337-000
	Screw, M6x70		0144-2131-923
	Lockwasher, M6		9213-0560-003
	Washer		0402-1107-500

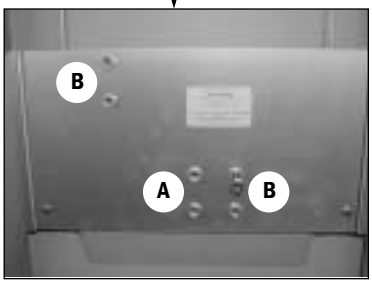
Not Shown

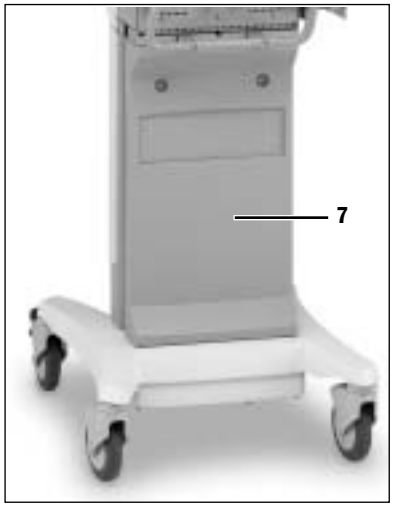
Hardware Kit	03-11-047
(includes hardware used to assemble base cart)	
M4 lock nut (6)	
M4 unthreaded spacer (4)	
Screw, #10x1/2 Hi-Lo (6)	
Screw, M4x8 Nylock (8)	
Screw, M4x16 (8)	
Screw, M6x16 (10)	
Screw, M6x12 (4)	
Screw, M6x25 (12)	
Screw, M8x35 (2)	
Washer, shoulder (4)	
Washer, M4 flat fender (4)	
Screw, M8x35 (2)	

* **CAUTION**: Carts, which do not include AC Outlets, have a weight installed in the base (in place of the toroid). To reduce the risk of tipping the cart, do not remove the weight.





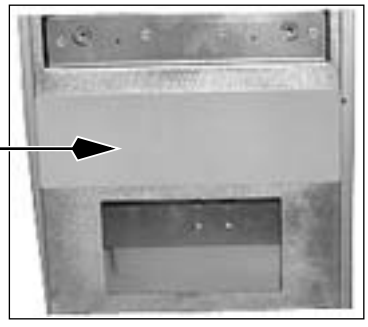


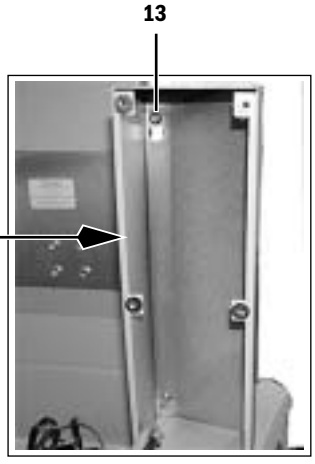


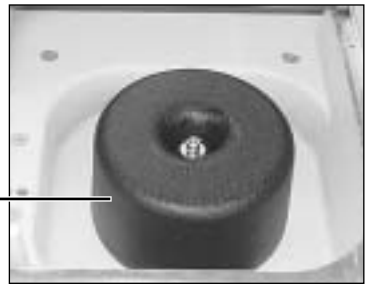
Note: For new installation of receiver assemblies (6), use the hardware provided in the kit to open mounting holes in the rear panel assembly (7). Thread the hardware from inside the cart at the locations that apply.

* Use location **A** for single receiver.

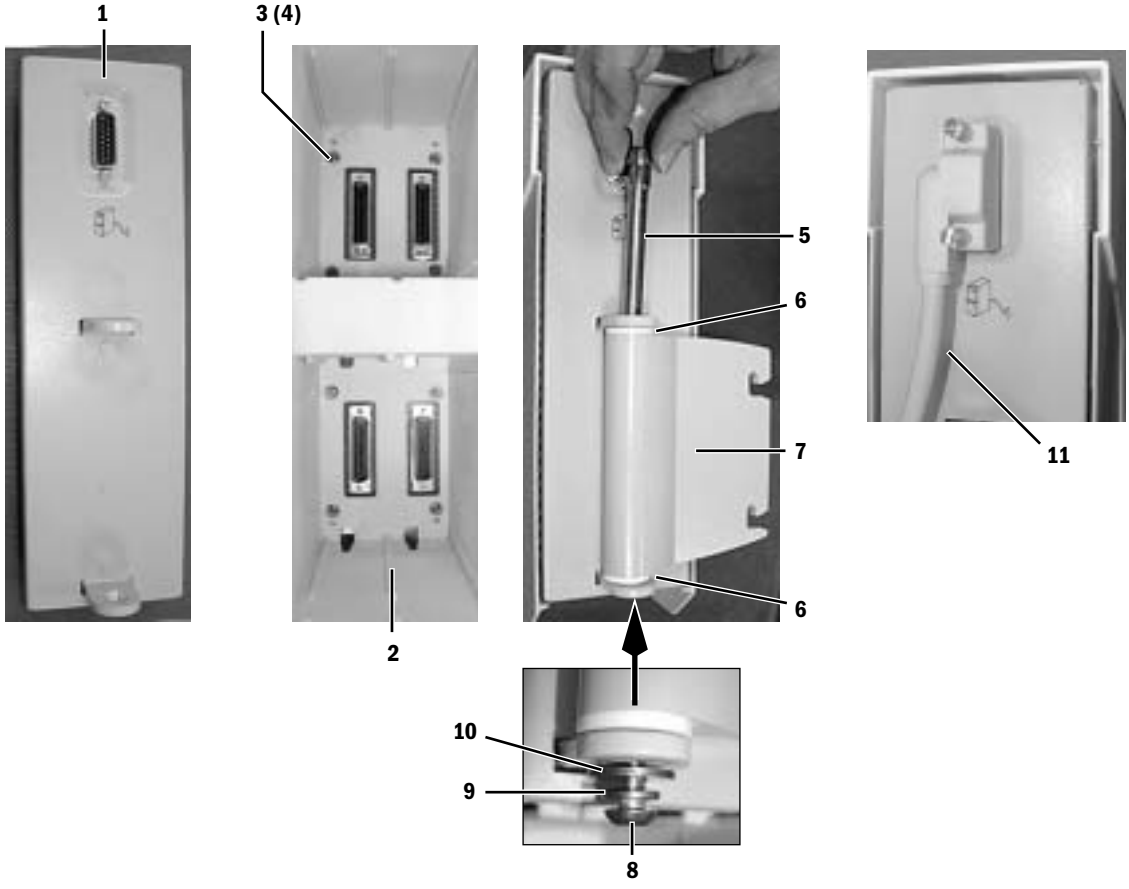
* Use location **B** for dual receivers.





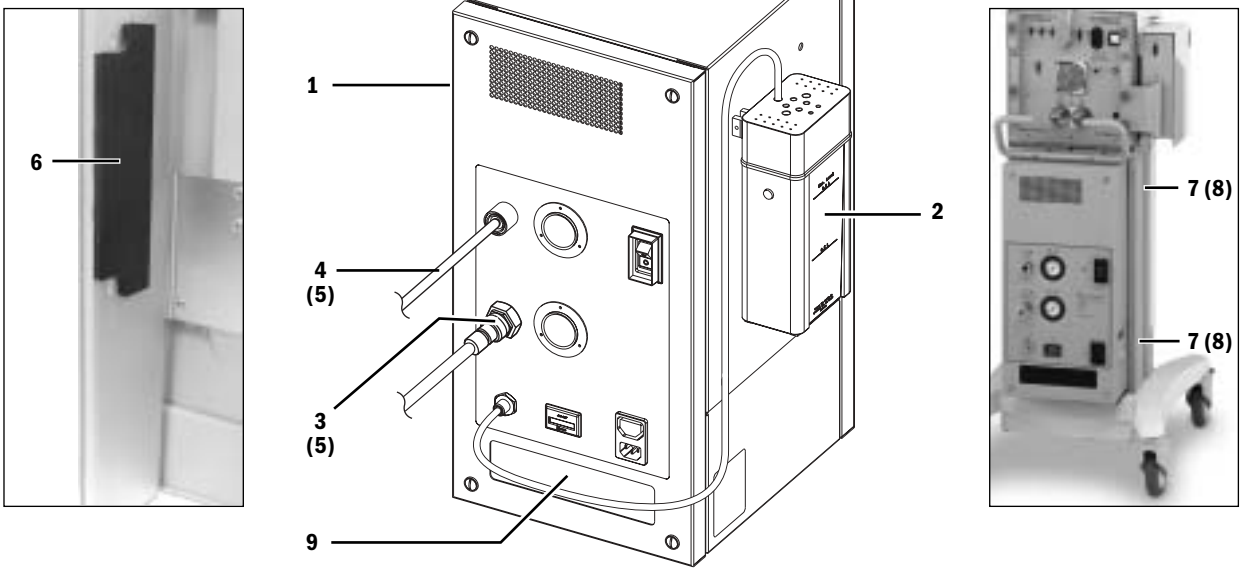


10.15 Module rack



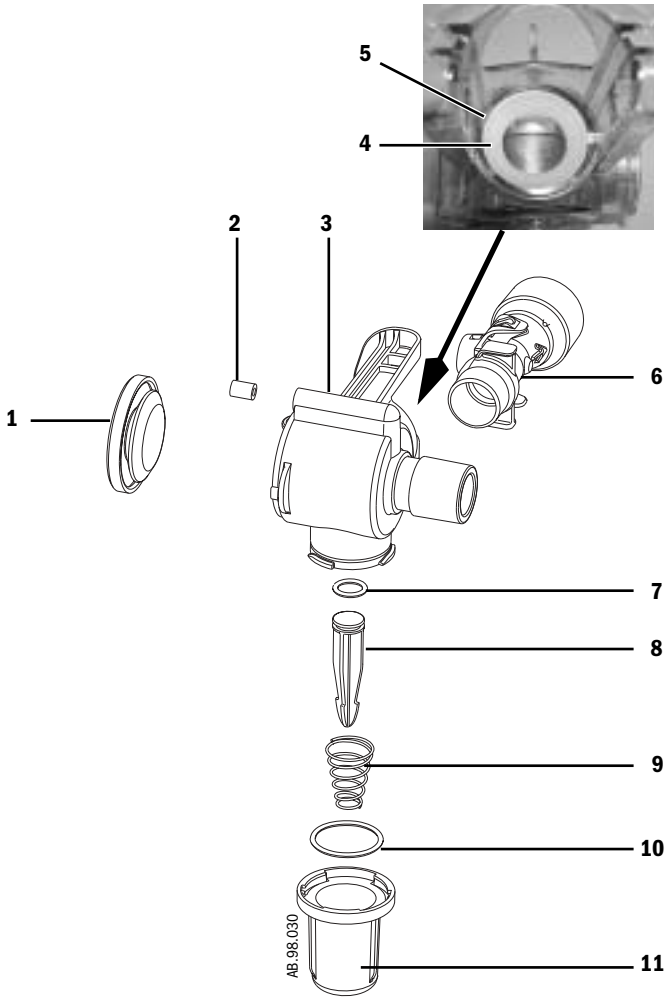
Item	Description	Stock Number
	Module Rack, complete assembly	1505-3849-000
1	Enclosure, Rear Module Rack (includes Module Interface Board)	1505-3803-000
2	Housing, Module Rack	1505-3802-000
3	Screw, M3x0.5-12 Pan Hd	1102-3078-000
4	Washer, Flat M3	0144-1003-132
5	Shaft, Pivot	1505-3832-000
6	Bearing	1505-3806-000
7	Arm, Module Rack	1505-3805-000
8	Screw, M6x16 Button Hd Skt drive	0144-2436-103
9	Washer, M6 Split Lock	N145402
10	Washer, Thrust	1505-3021-000
11	Cable, Patient Module Rack	1505-5601-000

10.16 Compressor



Item	Description		Stock Number
1	EVair03 Compressor, only	230V 50Hz	1609000
	for service information and parts refer to Jun-Air Compressor Technical Reference Manual — 6189655	120V 60Hz	1609002
2	Drain Bottle Kit		5612316
3	Inlet fitting, pipeline Air:		
	DISS		9913-6557-800
	DISS Female		1505-3830-000
	NIST		1001-5826-000
	S90-116	Fitting	1010-7048-000
		Seal	1010-3220-000
	SIS		1505-3831-000
4	Outlet hose, Air		
	DISS		1505-3810-000
	DISS Female		1505-3812-000
	NIST		1505-3811-000
	S90-116		1505-3815-000
	SIS		1505-3813-000
5	O-Ring -019 70 EPDM		1006-3614-000
6	Foam, Vibration Damper		1505-3829-000
7	Screw, M6x20 SHCS Shoulder		1505-3031-000
8	Washer, 6.35x11x2.4 Nylon Fender		1505-3034-000
9	Filter, air inlet		6985795
Not Shown			
	Trim, compressor Long		1505-3604-000
	Trim, compressor Short		1505-3605-000

Exhalation valve assembly



Item	Description	Stock Number
	Exhalation valve assembly (with flow transducer)	1505-3848-000
	Exhalation valve assembly (without flow transducer)	1505-8568-000
1	Diaphragm	1505-3224-000
2	Seal	1505-3223-000
3	Housing	1505-3222-000
4	Seal	1505-3257-000
5	Retaining ring	1505-3039-000
6	Flow transducer (includes check valve and screen)	1505-3231-000
7	O-ring	1503-3056-000
8	Plunger	1505-3245-000
9	Spring	1505-3013-000
10	O-ring	1505-3009-000
11	Water trap	1505-3244-000

11 Schematics and Diagrams

In this section

Schematics are subject to change without notice.

Circuit boards are available only as complete assemblies.

Figure 11-1 Pneumatic system. 11-2

Figure 11-2 Vent Engine manifold flow diagram 11-3

Figure 11-3 System cable/harness interconnections 11-4

Figure 11-4 Electrical architecture 11-5

Figure 11-5 Power distribution 11-6

Figure 11-6 Motherboard (backplane) block diagram 11-7

Figure 11-7 PMB block diagram 11-8

Figure 11-8 VMB block diagram 11-9

Figure 11-9 VCB block diagram 11-10

Figure 11-10 Monitoring Module Rack block diagram 11-11

Figure 11-11 Schematic, AC outlet module; 100–120 V (with isolated outlets) 11-12

Figure 11-12 Schematic, AC outlet module; 220–240 V (with isolated outlets) 11-13

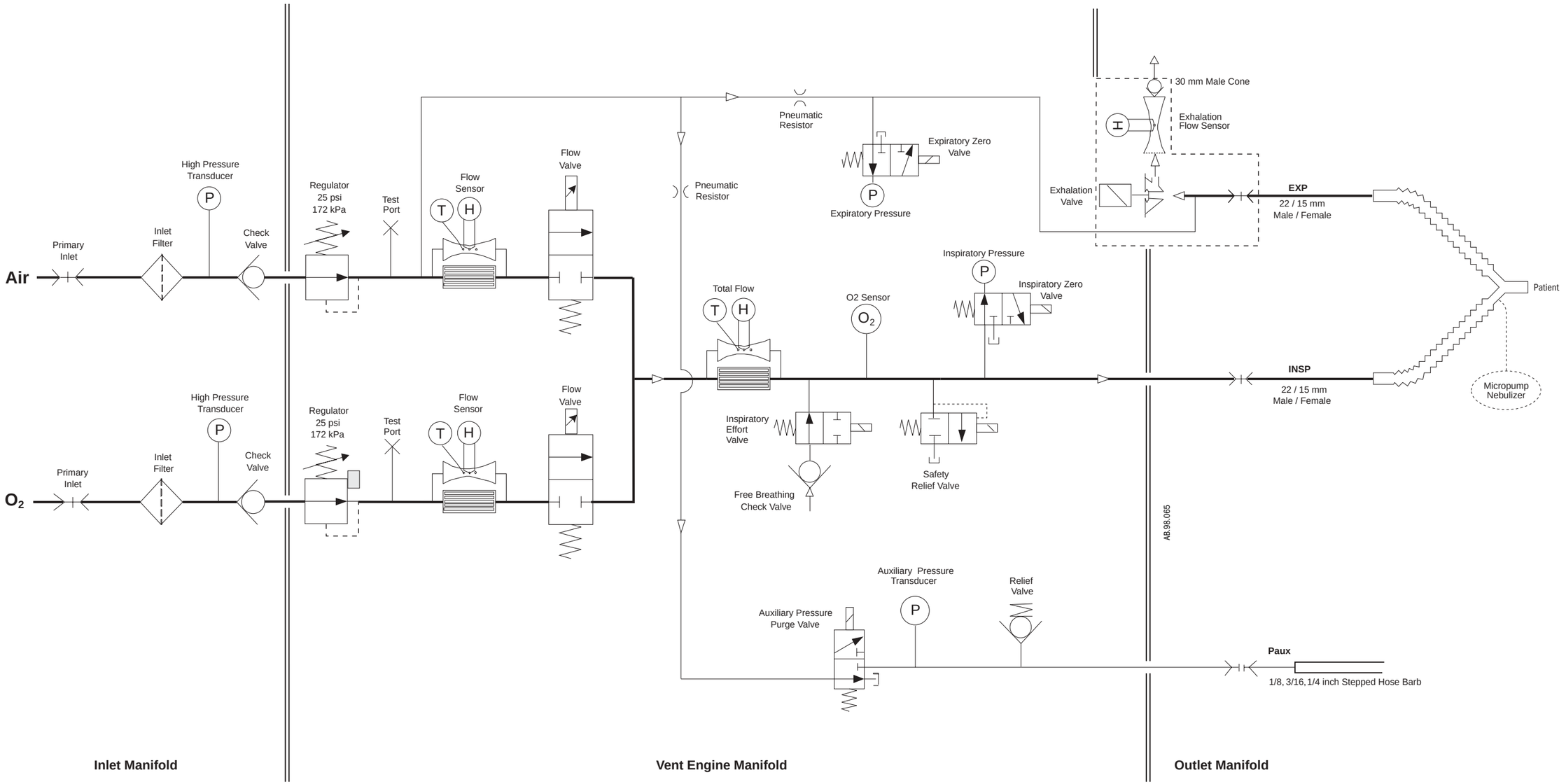


Figure 11-1 ▪ Pneumatic system

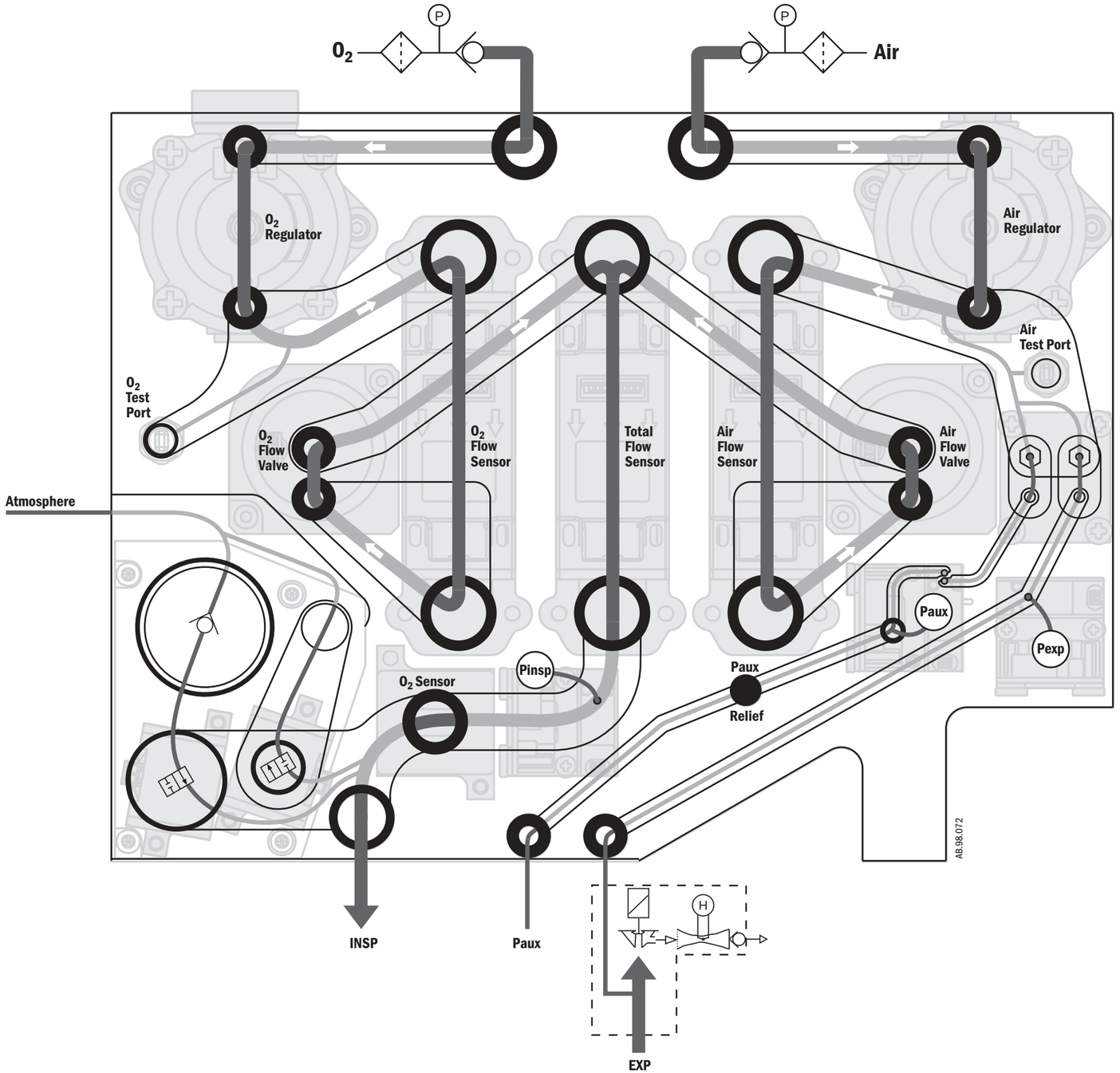


Figure 11-2 • Vent Engine manifold flow diagram

A: Display Unit cable

B: Monitoring module cable

C: Vent Engine harness

D: Battery to PMB harness

E: Power Supply to PMB harness

F: On/Standby Switch harness

G: External battery to PMB harness

H: AC Inlet to Power Supply harness

I: Flex cable

J: Nebulizer cable

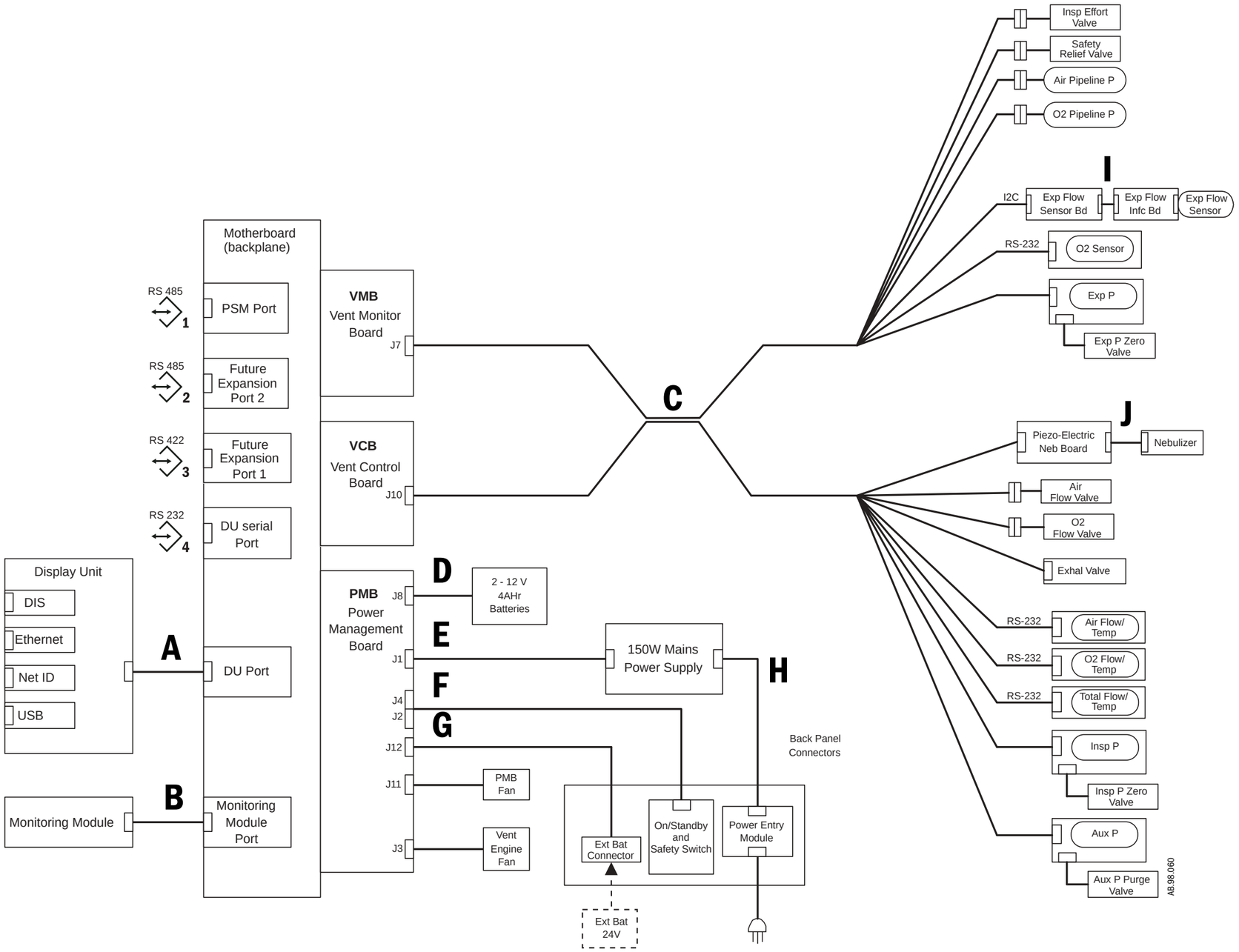


Figure 11-3 • System cable/harness interconnections

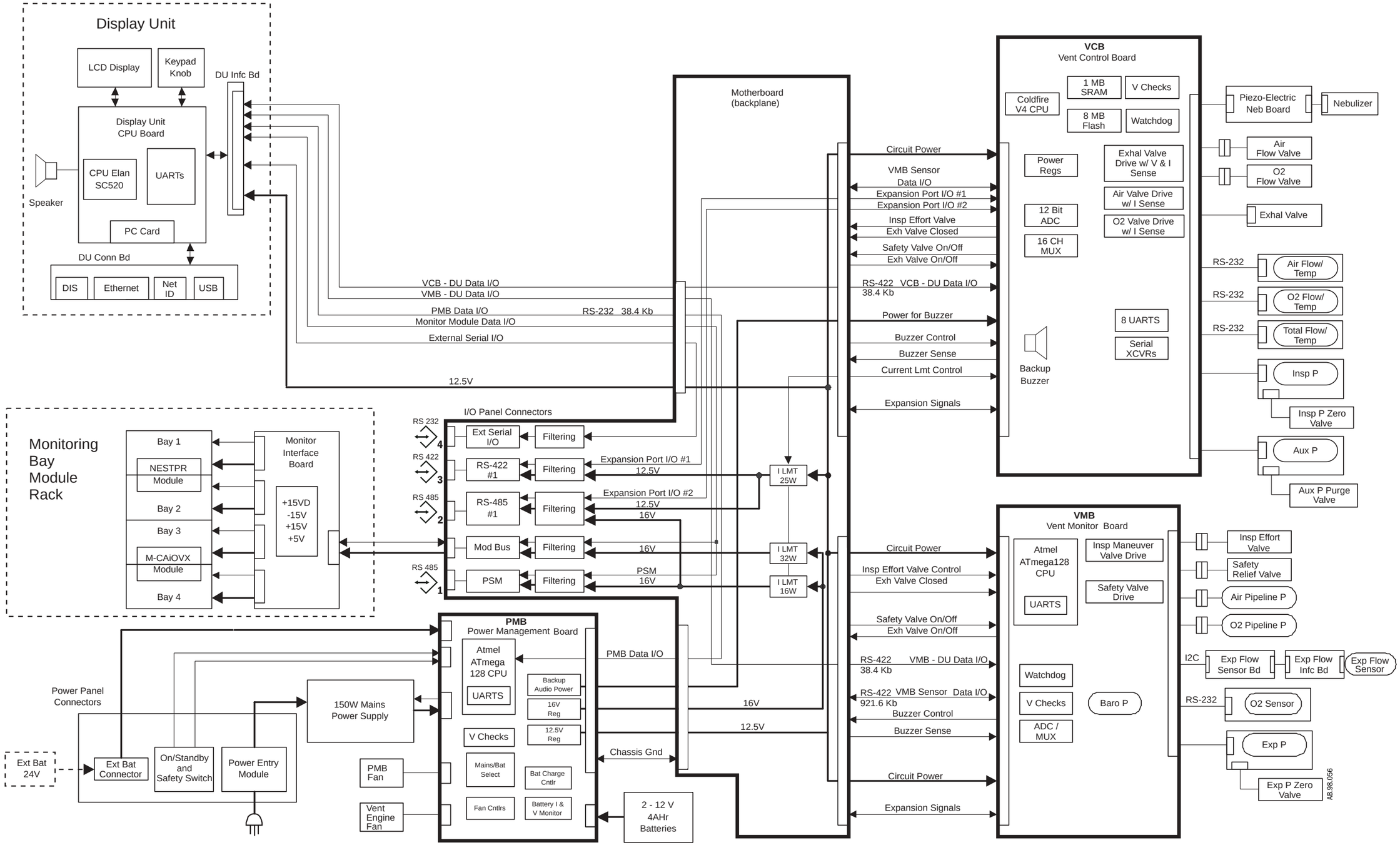
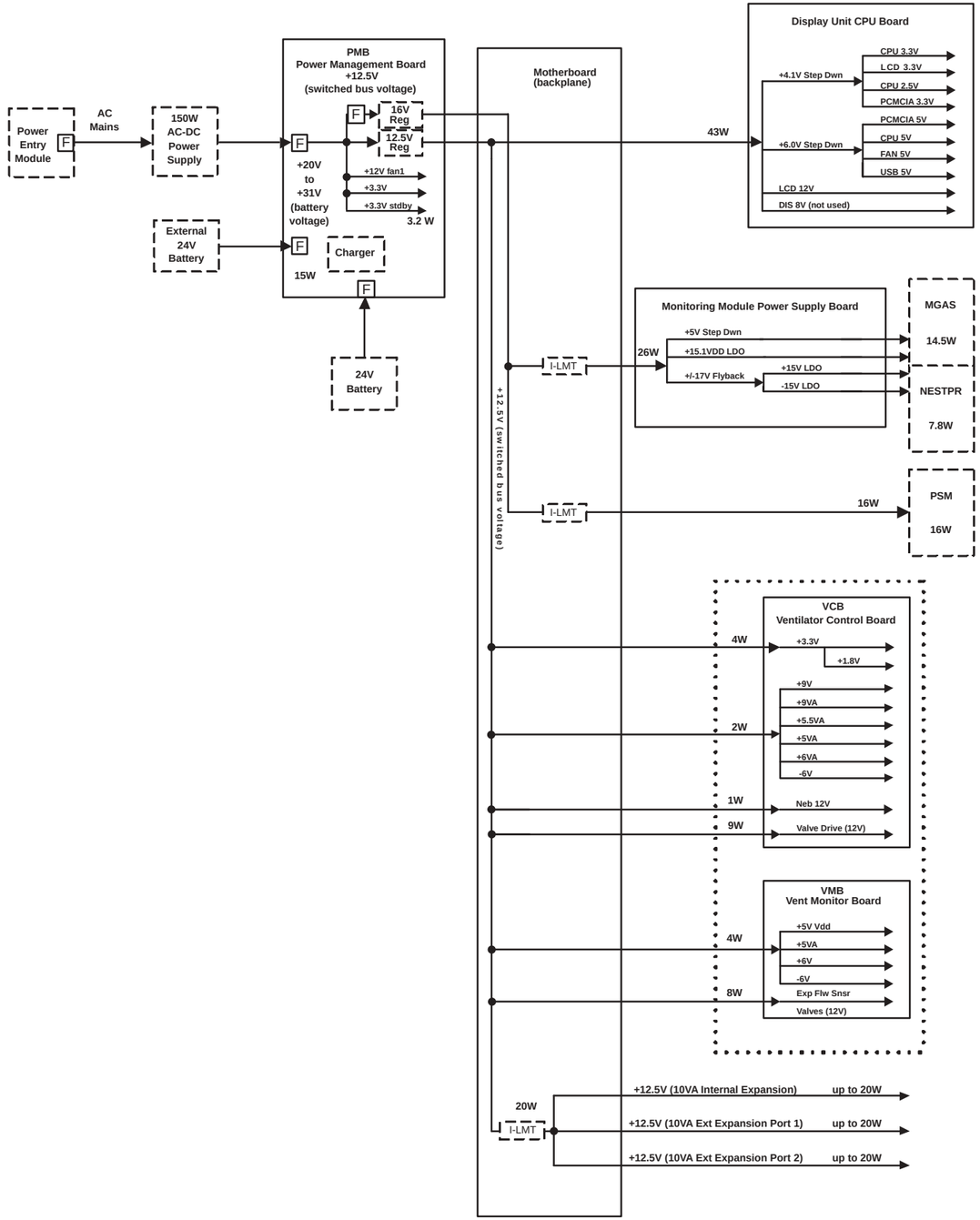


Figure 11-4 ▪ Electrical architecture



AB.98.059

Figure 11-5 ▪ Power distribution

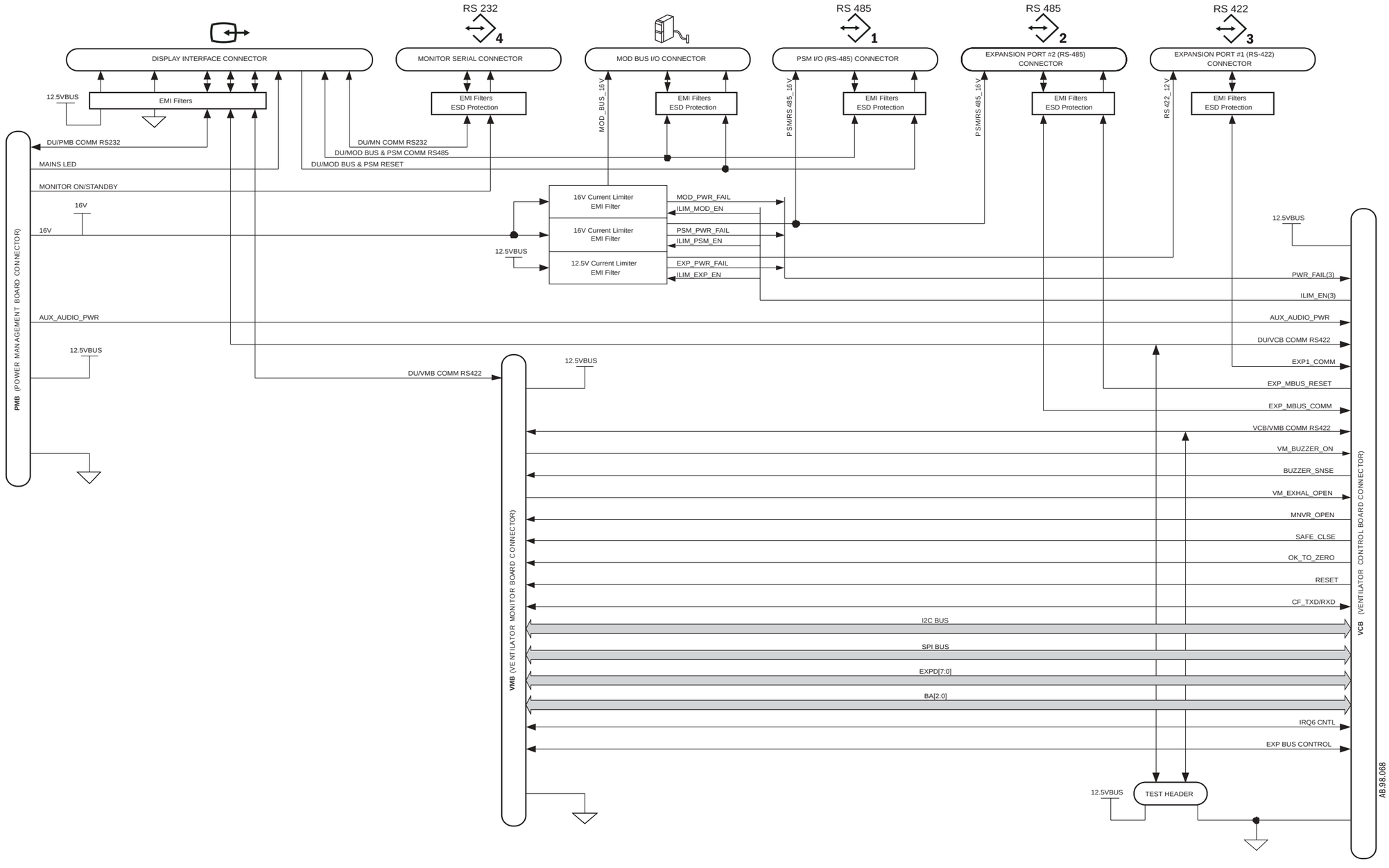


Figure 11-6 ▪ Motherboard (backplane) block diagram

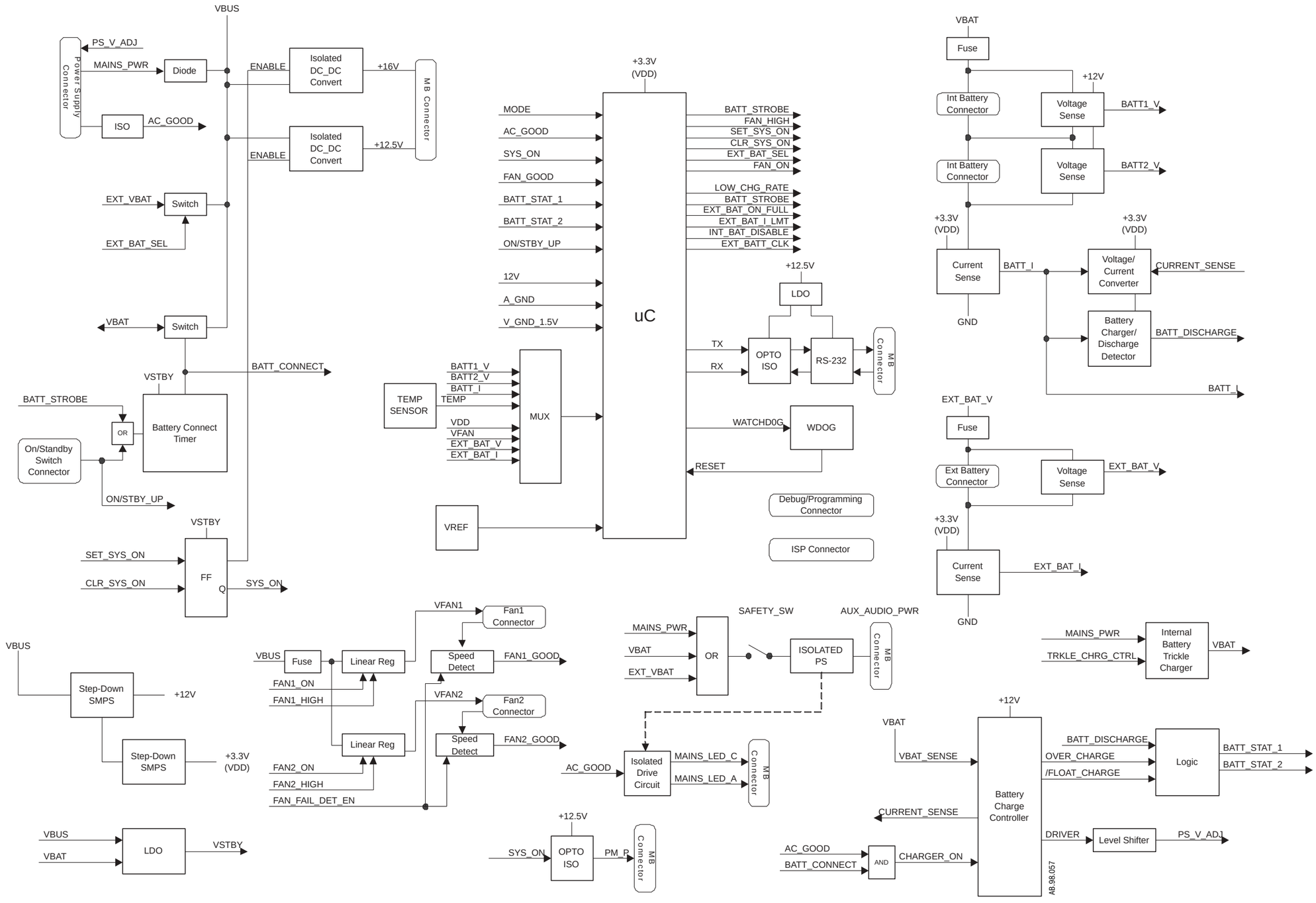


Figure 11-7 ▪ PMB block diagram

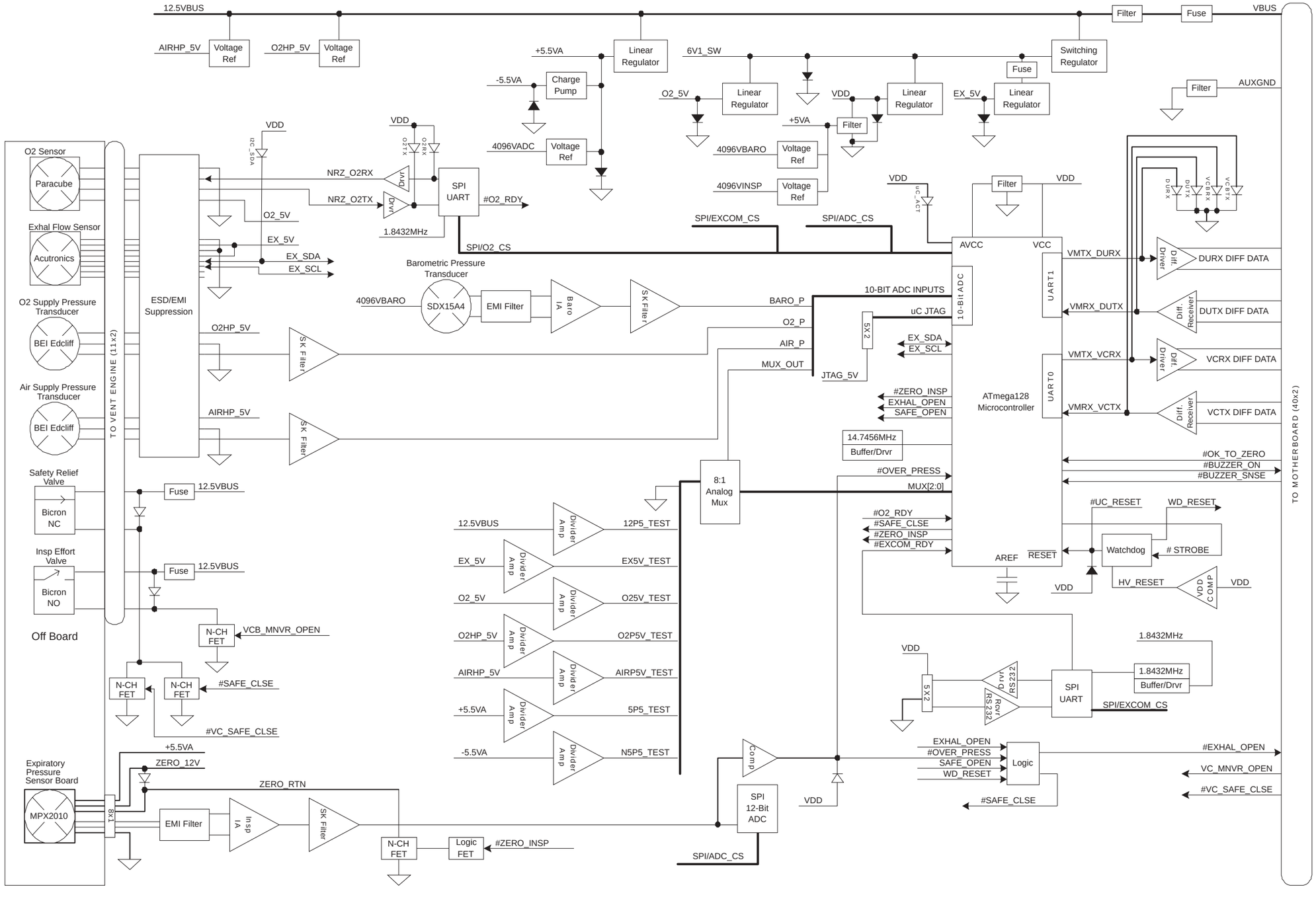


Figure 11-8 ▪ VMB block diagram

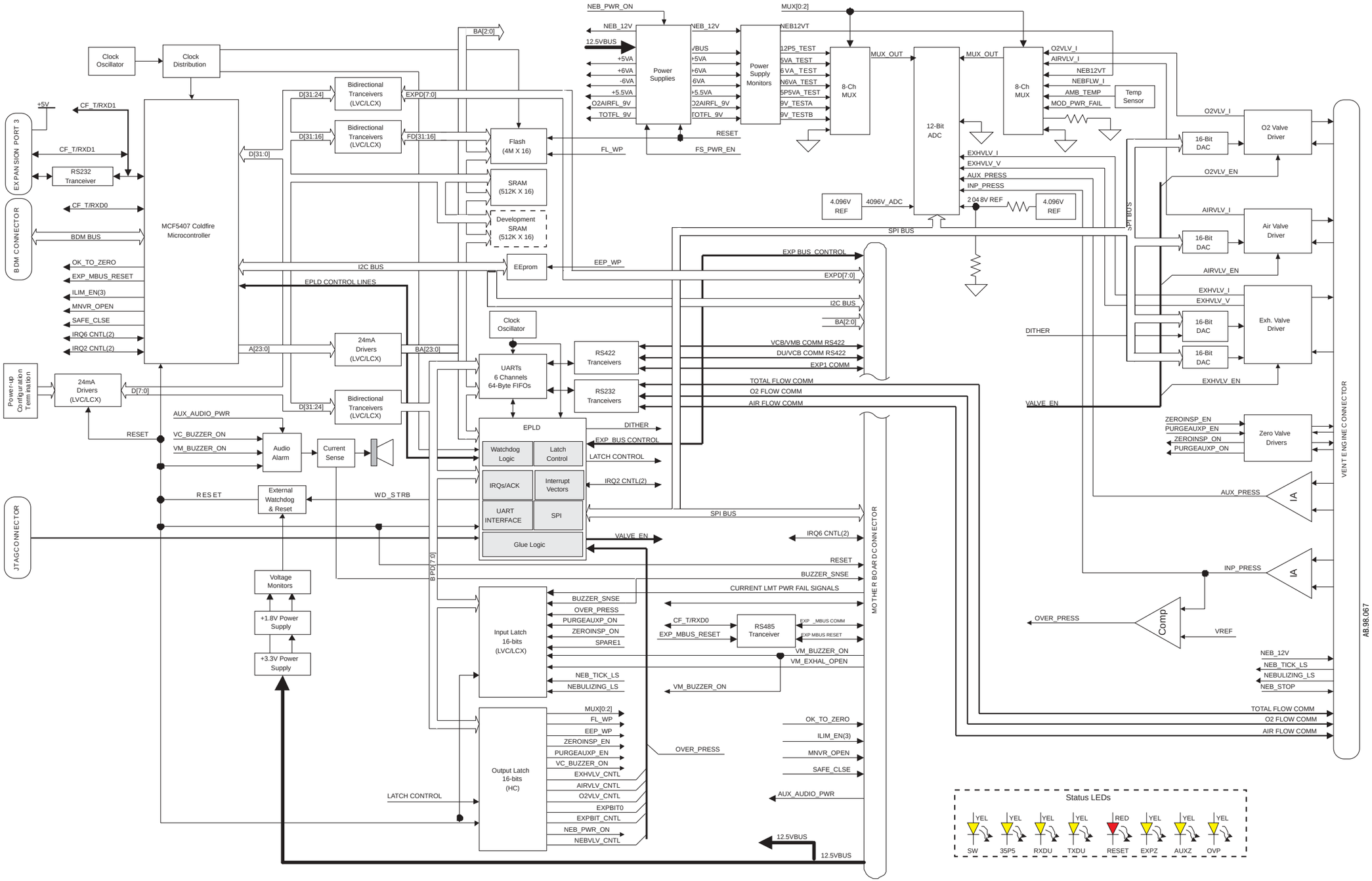


Figure 11-9 ▪ VCB block diagram

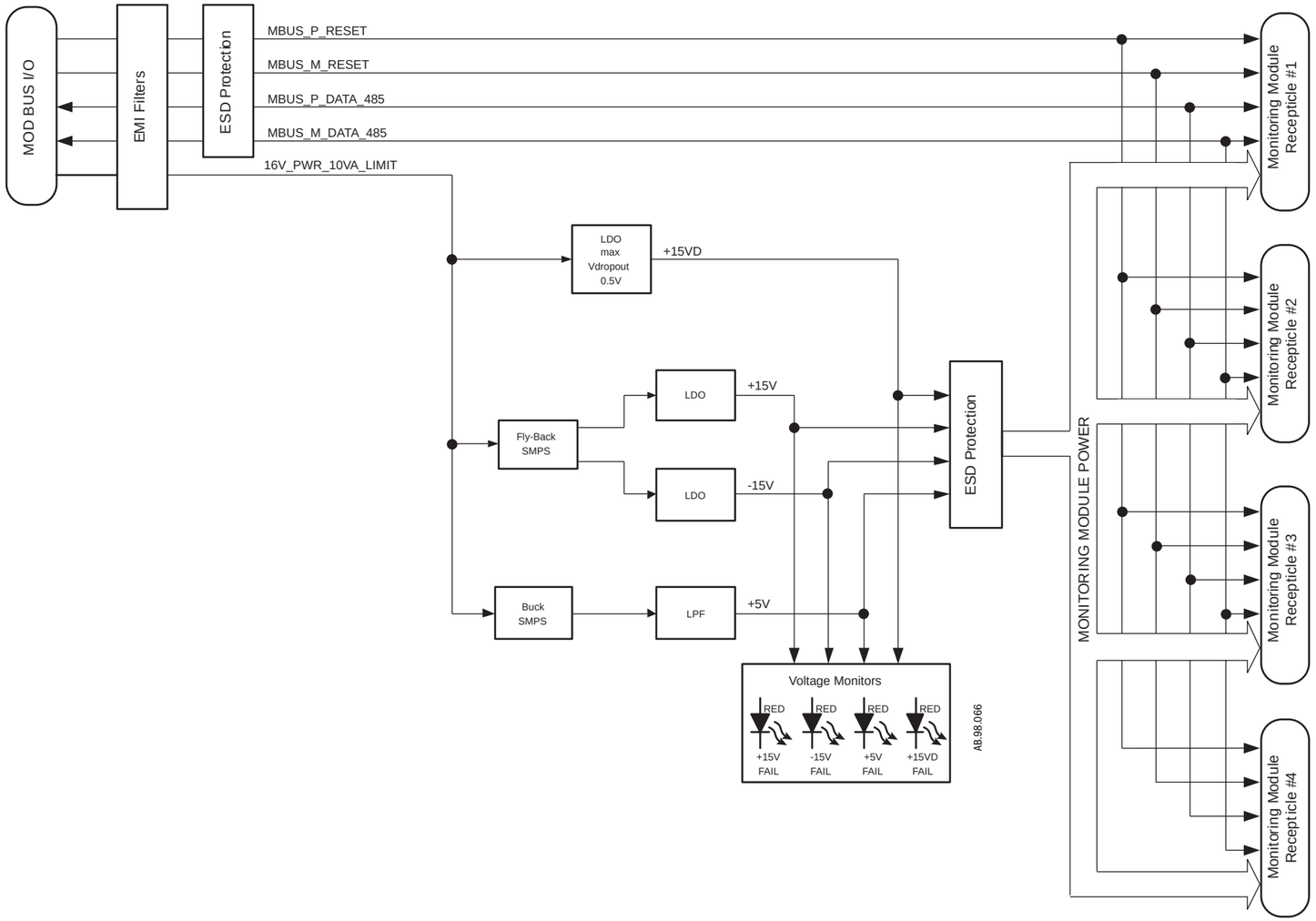


Figure 11-10 ▪ Monitoring Module Rack block diagram

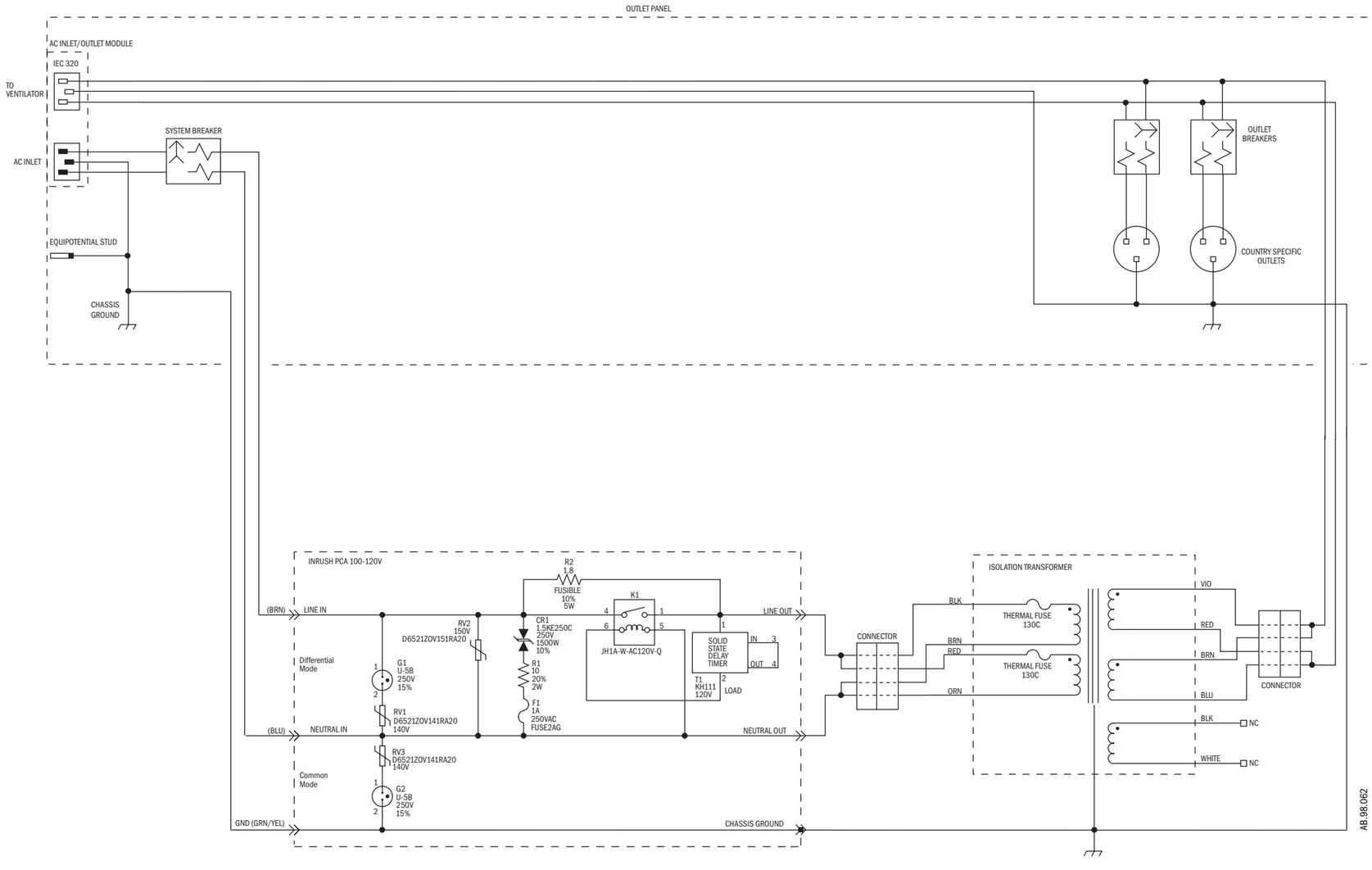


Figure 11-11 ▪ Schematic, AC outlet module; 100–120 V (with isolated outlets)

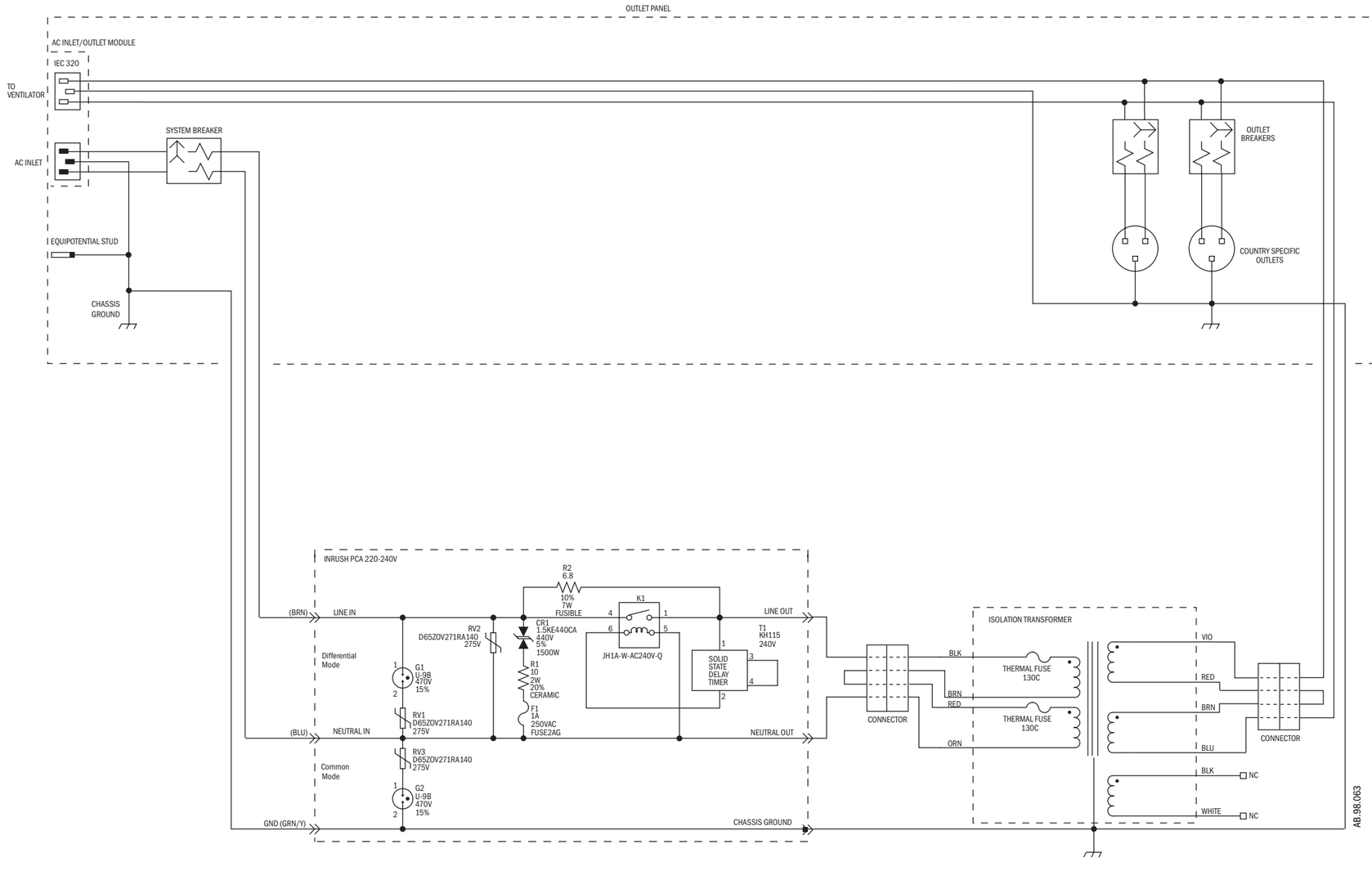


Figure 11-12 ▪ Schematic, AC outlet module; 220–240 V (with isolated outlets)

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